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The Journal of HEREDITY

A monthly publication devoted to Plant Breeding Animal Breeding and Eugenics

"TICKING"—A MENDELIAN CHARACTER

Quenching Farm Life *Student Ability for Three Generations*

Detecting Heterozygous Individuals with X-rays

Early Days of Rubber Experiments *Color Genetics of the Fowl*

Volume 19 NOVEMBER, 1928 Number 11

The American Genetic Association

An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks.

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IN THIS ISSUE

Detection of Heterozygotes with X-Rays
By Robert T. Hance 481

Early Days of Rubber Experiments 485

Quenching the Life of the Farm
By O. F. Cook 487

The Inheritance of a Ticking Factor in Hounds
By Leon F. Whitney 499

Genealogy Correlations of Student Ability
By Howard J. Banker 503

Hybrids of the Hautbois Strawberry
By G. E. Waldo and G. M. Darrow 509

The Genetics of the Domestic Fowl
Abstracted by L. C. Dunn 511

Variegation and Chromosomes in Petunia
By Edmund Malinowski 521

BOOK REVIEWS

The Tropical Crops 497

Selective Fertilization 508

Animal Genetics and X-Ray Mutations 508

The Proved Sire in Dairy Improvement 520

COMING

The Mangosteen in America

The "Queen of Tropical Fruits" begins to be at home in the New World.

Integumental Grafting in Fowls

A new light on the genetics of secondary sex-characters.

A Claw-Fingered Family

Claw-like nails on fingers and toes for three generations.

Inheritance of Left-Handedness

Left-handedness inherited—But how?

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GREY HAIR OF RAYED HETEROZYGOUS MICE

Frontispiece

The white mouse at the left of the illustration is the mother of the agouti litter of four shown at the right. The father was a pure-bred agouti. The three lower mice at the right have been given the shortest exposure to x-rays that would cause the hair to fall out. At the time the photograph was made the hair had regrown and was largely white. The greyish color shown in the illustration is due to a mixture of white and agouti hairs as all of the colored hairs were not whitened. The fourth mouse of the progeny (at top) was the control, and was not subjected to x-rays.

DETECTION OF HETEROZYGOTES WITH X-RAYS

Difference in Strength of Genetic Characters Resulting from Single or Double Genes Shown in Case of Color in the Mouse

ROBERT T. HANCE

The Rockefeller Institute for Medical Research, and
The University of Pittsburgh

THE distinction between organisms that are homozygous or heterozygous for a given character is, to a very large degree, demonstrable only by the appropriate breeding tests. There are, of course, a few outstanding examples like the cross of the red and white four-o'clocks[1] where the recessive white dilutes the dominant red to a pink in the F_1 generation. In the majority of cases, however, it is impossible to distinguish between an F_1 hybrid and the pure dominant. To use a concrete illustration, the offispring of the cross of a pure agouti mouse with an albino are indistinguishable from the issue of a pure agouti father and mother. In the first case, but one gene is responsible for the pigmentation while in the pure bred offspring the color is determined by a gene from each parent. There is no available evidence to indicate that the extra color gene in the homozygous mouse represents or produces anything physiologically different to that found in the heterozygote. Logically it has always seemed reasonable that a character supported by two determiners would be "stronger" than one dependent on a single gene. The proof for the correctness of this belief in one instance is submitted below.

During these studies on the biological effect of x-rays it was found that, following certain conditions of raying, the pigmented hair of mice is shed and is eventually replaced by hair that is white.[2] Miss Hatop, of the X-ray Division of the Rockefeller Institute, raised the question as to whether there might be any difference in the reaction to x-rays of mice homozygous or heterozygous for hair pigmentation. This was obviously an important point although at first the possibility of conclusive results with the available methods did not seem great.

The plan of attack involved a general exposure of a number of homozygous and heterozygous agouti mice at what had been determined to be a reactive age, from ten to fourteen days. The exposure used was the smallest dose that was known to cause the falling out of hair, on the general supposition that if there was a physiological difference between pigmentation that had resulted from either one or two genes a small dose might serve to change the weaker without affecting the stronger genetic character. The details of x-ray treatment are to be found in a previous paper dealing with this investigation.[2]

Differences in Reaction to X-Rays

The expectations were entirely realized with certain important and unanticipated additions. The regrown hair on the rayed backs of heterozygous agouti mice came in a mixture of pure white and pure agouti hairs in ratio of approximately from 3 to 4 white to 1 colored. The general effect of the mixed hair was light gray as can be seen in the photographs (Frontispiece). There was some tendency for the general color effect to become lighter as the animal became older. I am not certain whether this is due to whitened hairs becoming still more

white or to colored hairs dropping out.

A few of the hairs on the backs of the homozygous agoutis also came in white but the majority of the hairs were noticably darker than normal.

There was also a difference between the skins of the hybrids and pure bred mice after the original hair had fallen out following exposure to x-ray. The skins of the heterozygous agoutis became very slightly darker than the controls but that of the homozygotes was much darker. Whether this is pigment in the skin or merely an appearance produced by the darker hairs about to come through has not as yet been determined. I am inclined to believe that both suggestions may be true.

These results have been constant and without a single exception in six litters of homozygous agoutis (14 animals) and four litters of heterozygous agoutis (13 animals).

The above data seem to prove beyond question that a dominant coat color character that has been produced by a single determiner (in other words, one that is heterozygous) is not as "physiologically strong" as the same color resulting from two determiners (homozygous). Why is it that this is true? A suggestion may be hazarded on the basis of experience obtained from x-raying mushrooms and potatoes.[3]

A Tentative Explanation

It has been demonstrated that for the formation of melanin the enzyme tyrosinase is present in great quantities in potatoes and mushrooms. A water extract of these two plants when added to a solution of tyrosine oxidizes the latter to form melanin. When potatoes and mushrooms are subjected to x-radiation preceding their extraction the amount of melanin formed following the mixture of the extract with the tyrosine solution in the test tubes is in direct proportion to the length of the exposure. This indicates that the activity of the enzyme tyrosinase has in some way been increased.

Pigmentation in the hair is considered to have the same general chemical composition, *i. e.*, a color base, tyrosine, must interact with an enzyme, tyrosinase, to produce the colors we are familiar with. If either of these are lacking an albino results.[4]

There would seem, at first thought, to be little in common between the destruction of the color of the hair of mice on one hand and the stimulation of the oxidizing power of the enzyme tyrosinase on the other. Indeed, if it were not for the darkened color of the coat of the x-rayed homozygous mice reported above it would be much more difficult to understand what was taking place. In the latter case color production has obviously been increased and consequently we seemingly have in these animals an exact parallel to what takes place in the two plants following similar treatment. It is also clear from the behavior of these plant extracts that there is present at the time of exposure a large quantity of the enzyme stored probably in the cell sap. In the case of animals it is questionable whether there is any appreciable amount of the enzyme in the cells concerned although these cells must have the power of making as needed the necessary substances for melanin formation. It seems likely from the results obtained, that while x-rays stimulate the enzyme when they act on it directly when they act on the cell organs concerned with its manufacture complete inhibition of this power follows under the conditions usually employed. The proper exposure, as indicated in the results on homozygous agouti mice, apparently has the power of stimulating and increasing normal pigment production just as occurs in the x-rayed potatoes and mushrooms. On the other hand it is clear that there is a difference in the resistance to x-radiation of the pigment producing powers of the hair cells of mice depending on the genetic constitution of this character. Color

HAIR REMOVED BY X-RAYS

Figure 1

Below is the unrayed mother mouse. The two mice above had been exposed to X-rays ten days before the picture was taken. The hair will regrow and will be either white or darker than it was originally depending upon the heredity of the mouse and the length and the intensity of the exposure.

that is produced by two genes has proved more resistant to x-rays than the same character resulting from but one gene or determiner and the only apparent explanation of these reactions is that the former is literally stronger than the latter and consequently requires more radiation to kill it. This suggestion gains support from the fact that more severe exposures to x-rays will produce similar results in the homozygous mice while the difference between the pure bred and hybrid animals appears only when minimum doses are used.

Summary

1. When given a certain exposure to x-rays the pigmented hair of colored mice falls out and is replaced with uncolored or white hair.

2. This reaction has been found to be in part a function of the genetic

DARKER HAIR OF RAYED HOMOZYGOUS MICE

Figure 2

The mouse at the top is the mother of the litter shown below her and was a pure-bred or homozygous agouti. The father was also homozygous agouti. The two mice at the left were given the same exposure to x-rays as were the mice shown in Frontispiece. The hair in these cases regrew but was darker than that of the control mouse on the right. The high-lights of the photograph prevent the difference of color between the control and the x-rayed animals from showing, but it can be seen that the hair is not whitened as was that of the heterozygous mice (see Frontispiece).

constitution of the rayed mice. The hair of mice pure for pigmentation becomes on the whole darker in color while hybrid mice almost completely lose their original color. This suggests that this character, when determined by two genes, is "stronger" in its resistance to x-rays than a similar character that has been produced by only one gene.

3. A tentative explanation based on the observed increase of oxidative activity of tyrosinase following x-radiation is suggested.

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EARLY DAYS OF RUBBER EXPERIMENTS

A Letter from Dr. Ridley Pictures Singapore of Thirty Years Ago

A LETTER received recently from Doctor Ridley throws an interesting light on the pioneer period of the rubber industry as treated in the May number of the *Journal*. It is plain from this letter, as from Ridley's published statements, that he did not appreciate at the time the importance of his discovery of a method of tapping the rubber trees. It is hardly possible that any important discovery should be adequately appreciated at first. Often the recognition is delayed to later generations, and the graves may be hard to find when the time comes for placing the monuments.

Nobody could foresee the development of a rubber-planting industry with such unexampled rapidity, which in a few years transformed the Malay region and changed the lives of millions of people over the whole civilized world. To have witnessed these changes from the very beginning must be a unique satisfaction and a continual surprise. Probably no single discovery in the whole course of human history has changed the world so rapidly as the extensive use of rubber, developed through Ridley's discovery. The native method of tapping Hevea in Brazil was not adapted to plantation purposes, and another method had to be applied before there could be a practical outlook to regular plantation production. Many other discoveries contributed to the rubber development, but the tapping method was an essential feature.

That the early conditions at Singapore were those of a mining-camp, rather than of an agricultural community, renders it the more remarkable that the particular steps should be taken that led to a practical solution of the problem. There were endless ways for such an experiment to miscarry, even after the first stage of the introduction had been accomplished. Obviously, everything depended on the presence of one man with a naturalist's persistent interest in the living world. The strange habits of the monkeys, the ants and the Brazilian rubber trees could hold his attention, and he would not be distracted by tin mines, or even by gold mines! Nobody without that particular kind of biological interest would have learned how to tap the Brazilian rubber trees in a new way. Without the scientific interest, the lack of official encouragement would have been fatal.

But let Ridley tell us why he did not report his discovery more prompt-

ly and adequately, and show us incidentally what the local conditions were when the discovery was made. The letter was not written with any thought of publication, but is not less interesting on that account.

7 Cumberland Road,
Kew, Surrey.
June 11, 1928.

DEAR DR. FAIRCHILD:

Very many thanks for the highly appreciative account of my rubber work in the JOURNAL OF HEREDITY. Mr. Cook seems to be puzzled as to why I published no articles on rubber cultivation before 1897. This is easily explained. The only printers in the Straits were two daily journals which were fully employed and never printed anything but their journals and the Government Printing Office run by a halfcaste. When this office had nothing to do (and the printer was sufficiently sober) I could get something printed but this did not happen every year. The first paper I got them to print was one definitely ordered by the Government and after I had sent it in a year and a half I called the attention of the Government to the delay and the Colony Secretary who had ordered its printing a year and a half before fell upon the printer and got it done. Our Natural History Society, the Straits branch of the Royal Asiatic Society, elected the printer as a member and backed by subscriptions from the rest of the Society I got that done, but I could not do that with a Government publication, which had to wait its opportunity for years. I had no funds to print anything and the Government never saw any reason why I should print anything. Eventually an American mission press turned up prepared to print anything. I got subscribers, took the whole thing out of Government hands and ran it myself, independently, and brought out journals regularly.

Before the rubber boom there were not nearly enough subscribers to run a journal independent of Government. There were very few planters, only a dozen or so planting coffee and they could not finance a journal, they were mostly bust! So with no subscribers, no money and no printers how could I publish anything? I may tell you the starting and establishing the rubber industry cost the Government of the Straits Settlements nothing at all. I got an advance of £100 for experiments from them once and paid it back next year out of sales of the rubber made in the experiments, and it cost the Federated Malay States less if possible!

We were a pretty primitive lot in the nineties. The Government despised agriculture, hated the name of science, and depended on tin and other minerals and trade, and put me on to do the mineral work for them when I first came, and I did find a gold mine for them once. It's buried under rubber now. I also sought for coal, etc. Of course I was the only naturalist there except a man who collected birds and butterflies. It was a very jolly time, however. Nothing whatever known of the natural history or agriculture, and everything to be done by one man, or at least started by one man. It is difficult now to realize what the state of a little colony like the Straits Settlements was in those days. A regular backwoods establishment then, but these reminiscences may bore you.

So thanking you again for all you have done, I remain,

Yours sincerely,
HENRY N. RIDLEY.

Brazilian Rubber Tree Introducer Dies

The death of Sir Henry Alexander Wickham on September 27, 1928, at his home in London, is announced in the newspapers and rubber journals. Wickham brought the principal shipment of rubber seeds from Brazil to the Kew Gardens in 1876. He was born May 29, 1846, and was 30 years old when the rubber introduction was made, for which he was knighted many years later, in 1920.

According to a statement in the *Rubber Age* of October 10, 1928, an annuity was established for Wickham in 1911 by subscriptions from "the rubber industry throughout the world." In October, 1926, the Governments of the Straits Settlements and Federated Malay States made a grant of 8,000 pounds to this "Grand Old Man of the Rubber Industry." A few months before this, in May, 1926, testimonials to the value of 6,000 pounds had been subscribed from American sources, as announced in journals of that period.

It is no detraction of the services of Wickham to the rubber industry to point out that those of Ridley were at least as great, and equally indispensable for opening the way to plantation production of rubber.

QUENCHING THE LIFE OF THE FARM

How the Neglect of Eugenics Subverts Agriculture and Destroys Civilization

O. F. Cook
Bureau of Plant Industry

(*Concluded from October Number*)

Urban Control of Agriculture

FARMERS laugh at foolish advice in the city papers, but urban control of agriculture is an outlook for the future if tendencies now apparent continue to develop. Many farmers are taking orders as well as loans from merchants or bankers, and urban capital is found for large projects of industrialized agriculture. Some of these undertakings are in foreign countries where land and labor are cheaper, but even in the United States urban farm projects seem to be increasing in spite of many failures in the past. Eventually they may succeed, like the system of *latifundia* which developed in the Roman empire after the original farm population of the republic had disappeared. With the more competent farmers dropping out of the equation, production would be left to peasants on small holdings or to laborers on large estates. The large operations may have more competent supervision and may produce more efficiently. It then appears in order for the large properties to absorb the small holdings, as in the Roman system, and this is the course of events that the bankers and industrialists are beginning to foresee. Farm lands are being considered as permanent investments and the management of estates for non-resident owners is becoming a recognized profession in the United States as in older countries. Eastman projects the future of industrialized agriculture as leading inevitably to extinction of all that now remains of the democratic farm life of America.

Another much discussed plan of farming from a production standpoint is corporation farming. How often city business men say that all agriculture needs is the formation of great corporations with successful managers, boards of directors, which would control and farm thousands of acres in one unit, where a large enough production would insure the best use of machinery, capital for the best stock and for the most efficient operation, the sale of products in carload quantities, and so on.

The proposition certainly sounds well—on paper, but it is a strange fact that there have been many trials of corporation farming, the great majority of which have ended in bankruptcy.

Farming more than any other occupation in the world, so far as production is concerned, is a particularly individualistic occupation or business. Yes, it is more than this. It is a life as well as a business. Without the family, the interest, the advice and the actual work rendered by all the family members, farming could not succeed. More than this, a general system of corporation farming in America would be one of the greatest calamities that could be imposed upon the nation, for it would reduce to a condition of peasantry the independent, individualistic thinking farmer who has contributed so much to the life of the country.

Today it is not material compensation that keeps the farmer and his family on the land. It is the love of country people for their environment. They work, and quite cheerfully, for small material returns knowing that they receive a larger compensation in those things which city folks cannot have. But once let them become the hirelings of a farm corporation, they would lose those unmeasurable compensations which the farmers now have together with their habits of constructive independent thought and action that have made the farm family the breeder of leaders in America." (Eastman, pp. 66-67.)

Many farm writers are misled by another urban argument, that it is desirable to reduce the number of farm-

ers as far as possible, and increase the cities still more, because this eventually will result in a scarcity of farm products, which will raise the prices and restore the surviving farmers to prosperity. As the merchant expects more business when he has fewer competitors, so it is assumed that the farmer will be advantaged by his neighbors' going out of production and moving to the city. Hopes are often expressed, and even assurances given, that a limit of urban expansion will soon be reached, when the currents of economic advantage will begin to flow back to the country. Accordingly, the rapid growth of the cities and the depletion of farming districts are being hailed by some writers as favorable signs that we are closer to the expected turn of the economic tide. This notion is found in most of the complacent farm books that are obscuring the danger ahead. Eastman gives a qualified assent to this argument for further expansion of the cities.

> Because of the increased modern difficulties of farming, which will continue to increase, it is going to require more and more skill to make a success in the farm business. This means that the untrained and the unfit will move out, lessening the competition, leaving a real business and a real future for the man who loves farm life and is willing to devote the same amount of study to the preparation for it as he would to any other trade.
>
> Another assurance of success for the right kind of farmer is the increasing number of consumers. These people who have left the country to go to the city and those who were already in the city must eat. They must buy and use the products which the farmers raise. Therefore, from an economic standpoint, the more of them, and the larger the cities, the better, providing always the farmer is of high enough intelligence and is well enough organized so he cannot be dominated and be made subservient to the cities." (Eastman, p. 233.)

The economic argument is stated in many ways, but may prove entirely deceptive. No practical reason has been shown for expecting any automatic balance to be reached that will advance prices, raise the quality of farmers and restore agriculture to a footing of equality with urban industries. The city sets the prices that the farmer receives for his crops, and also the prices that the farmer must pay for the goods that he buys in the city. Fluctuations of supply and demand alter the trading values of different articles, but the power of the city to lay its tribute on the country is not affected. Except that few producers might combine more effectively, nobody has explained why the city should be expected to pay a higher scale of prices for farm products to a reduced farm population. Fewer farmers mean fewer customers for the manufactured products of the cities, and a narrower support for the whole urban structure. Three million farmers are reported to have moved to the cities in recent years, and five millions more are condemned to go, according to some of our economic writers. Such changes constitute an industrial revolution, as in England a century ago, though it is hardly to be expected that the development of foreign trade can make good the deficiency of American farmers, as buyers of manufactured articles. The national interest in having as many good families as possible living in the country, is also overlooked by the argument for fewer farmers.

Farmers are extensive buyers of farm products of other regions, and the inter-farm commerce would be greater if incomes were larger. Costs are added by the city which interfere with the farmers serving each other. The consumption of farm products is restricted, to the advantage of nobody. Exchanges of wheat for rice, or apples for oranges, might go much farther than has been feasible in the past. Green vegetables in the winter taste as good to northern farmers as to city people.

The narrow urban view of agriculture is that the farmers are merely producers for the city, and are to be "occupied continuously" in order to make a living, while leisure for exer-

cise, sports, and amusements is considered normal in the city. No restriction has been set to the power of the city to assess profits on the producers. Urban property, rents, and other costs of living are always mounting higher, and the utmost exactions from the country seem always to be required. The only way that the farmer has discovered in the past to escape the burden of urban exactions is to get on the other side of the economic equation by moving to the city. Urban parasitism has no natural limit until the life of the race is consumed and the cities are no longer supported.

Each of our urbanized civilizations in the past has led to social stratification in one form or another, with the farm producers at the bottom doing harder work for a meaner living. A highly developed civilization has existed for many centuries in China, and shows the typical economic reactions. The Chinese farmers are incredibly hard-working people, who seem to have no share in the civilization that they support. The houses they live in, the clothing they wear, and the food they eat, are no better than among the natives of West Africa, where no civilization was developed. A residual peasantry is the normal product of urban selection. Instead of a favorable rural reaction being induced by our rapidly increasing urbanization, tenants and crop-loaners are taking the places of farmers who owned their land and had better standards of living, which they were not able to maintain. Some of our farm writers apparently are reconciled to the peasant status for American farmers, in comparing our present farm conditions with those of European peasants.

Cities mark the advance of civilization, because agriculture must develop to a certain stage before urban populations can be supported, but the confusion of urbanism with civilization is a fundamental mistake. Progress begins and must continue in the country if cities are to be maintained. Cultivation makes it possible for families to have a settled life and to form communities where the social and economic specializations may develop. Primitive people make progress by discovering more kinds of food and more ways of storing and preparing food. Fire is domesticated as well as plants and animals. Better tools, houses and clothing are contrived, with endless comforts and conveniences that enrich family life. Products of different districts are exchanged, and eventually such exchanges become world-wide. Bartering-places at cross-roads grow into permanent market towns where merchants are supported by trade, without the need of producing anything for themselves. The artizans associate themselves with the merchants for quantity production of articles of trade, the home industries giving place to machines and factories. The merchant takes little at first, but the "rake-off" gradually increases until the "cost of selling" a farm product is more than the farmer's return for producing it. Thus the activities and resources of the race become centered in the cities, and the rural interests are left in the background. Eventually it is seen that the system has culminated and is taking the down grade, but too late to return to a condition of normal adjustment and restore the constructive functions of agriculture.

Extent of Rural Depletion

If the country seems dead it is because the life has gone to the city. No other effect could be expected from the selective draft that has acted so powerfully in many rural districts. How far the process of rural depletion has gone in the nation as a whole, and how it can be arrested and reversed, are questions that need greatly to be studied, instead of ignoring the danger that is definitely indicated by our present knowledge of the effects of selection, and the testimony that many writers have given.

. . . . . The third generation of farmers in my native town are much like the third steeping of tea, or the third crop of corn where no fertilizers have been used. The large, picturesque, and original characters who improved the farms and paid for them are about all gone, and their descendants have deserted the farms or are distinctly of an inferior type. The farms keep more stock and yield better crops, owing to the amount of imported grain consumed upon them, but the families have dwindled or gone out entirely, and the social and the neighborhood spirit is not the same. No more huskings or quiltings, or apple cuts, or raisings or "bees" of any sort. The telephone and the rural free delivery have come and the automobile and the daily newspaper. The roads are better, communication quicker, and the houses and barns more showy, but the men and women, and especially the children, are not there. The towns and the cities are now colouring and dominating the country which they have depleted of its men, and the rural districts are becoming a faded replica of town life.*

It is known from the census that population and farm values have greatly declined in some of the rural districts, but even with stable or increasing populations, a decay of farm life may be going on. The decline of church organizations in rural districts has been considered as one of the symptoms of deterioration, and detailed investigations have been reported from several areas. A rapid depletion of the better elements of rural population is indicated from such studies.

The rapid growth of our cities has brought us two great sets of problems:—the first concerned with the social and industrial conditions of city life; the second with the country, both for its own sake and as the source from which the city draws not only its supplies of the raw materials of food, clothing, and shelter, but also the vigorous manhood and womanhood from which its power is chiefly derived. The removal of the best young people from the country to the city necessarily produces a decline in the quality of the country population which must be followed by a decline in its social and industrial life. This in its turn accentuates the relative attractiveness of the cities, and so the evil grows.*

To what extent the urban preponderance may be ascribed directly to the factor of selection has not been determined. No ways of measuring urban preponderance have been recognized, even by so simple a method as comparing the houses and household equipment of rural districts with those of towns that draw their economic support entirely from the surrounding country. Such comparisons in some parts of the country would show striking results. Even small market towns with only a few thousand people may have dozens or hundreds of houses which are better than any of the farm homes in the supporting country. The numbers or proportions of different classes of houses would give a rough indication of the extent of the advantage that has been obtained for urban activities and interests under our present commercial and economic system.

We have not maintained our pioneer traditions or asked ourselves squarely what social institutions or systems of education are necessary to develop an agricultural civilization, but have allowed masses of urbanized people from Europe and Asia to assemble in the United States in the last half-century. The true urbanites are not of our race, but have come to us from the oriental countries where cities have existed for thousands of years, and urban breeds of humanity have had time to develop. Needless to say, these urban populations do not understand or appreciate our democratic institutions, and may try to change them.

Farm Contacts for Children

The benefits of country life as tending to the advancement of a capable race are not imaginary or mysterious, but rest on the fundamental fact that under rural conditions children are raised by their parents. The children share the responsibilities of the farm and are in contact with the world of

*Burroughs, John. *My Boyhood*, pp. 10-11.
*Gill, C. O. and Pinchot, Gifford, 1913, *The Country Church*, pp. 3 and 4.

nature. City children are not raised in a world of adults but in a world of other children. In school or at play the children are by themselves, from the stage of infancy. The teachers conduct their classes, but the children are a separate social body. It is easier for the parents and the teachers to handle the children in bulk, rather than as individuals. As an effect of such segregation of children, many do not advance to the full mental stature, but remain permanently child-minded, as psychologists now recognize. Competent teachers of young children have testified to a frequent decline of mental ability and interest as an effect of school conditions. The normal function of the school is to supplement the home, as in the country, not to supplant the home, as in the city.

No business in the world is as closely associated with the home as is farming. No business gives the father such an opportunity of personal contact with his children. In the city, the father leaves in the morning before the younger children are up, and often he gets home so late that the children are in bed. If he sees them at all, it is when he is tired and worn from the labors of the day.

No place in the world equals the farm home for the rearing of children and for the opportunity of giving them the association with natural growing things of both plant and animal life, a place to play in the open air under natural conditions, and the fresh air and food of the farm to build their young bodies. No place in the world is so good as the farm in the training of both the boy and the girl in habits of work and responsibility that will mean their success later in life.

So, also, the farm home, perhaps in larger proportion than other homes, is the place where love abides. Problems of the business are mutual ones to be worked out by both father and mother together. Perhaps it is the soil and the natural things of life which surround the men and women of the farm which give them a deeper sense of responsibility and stedfastness toward each other, toward their community, their country ,and their God.

These associations and experiences the farm boy who has gone to the city never forgets. Whatever his so-called success may be, deep in his heart these memories are ever calling him back. No matter how high he has climbed in worldly power and material attainment, he seldom again is able to touch the high spots of happiness that come to those who work and live upon the land and who are able to appreciate and enjoy simple and fundamental happiness. (Eastman, pp. 244-5.)

The parental instincts are deprived of their normal satisfactions in the city, and the sense of responsibility is weakened. Most of the city people do not have lives that their children can take part in, or that they desire their children to follow in the future. Hence the assurance is welcome to urban parents that they are doing the "right thing" by their children to send them "away to school," and to keep them in school as long as possible. Even the holidays and vacations are too long for urban parents to be charged with the responsibility of their children. A large industry in camps and vacation schools has grown up in recent years.

Farm parents are influenced, of course, by all that they hear and see of the wonderful city schools, and believe that they must move to the city in order to give their children the "advantages." This is the mistake that millions are making now, but some are seeing the danger and seeking ways to avoid it. The people who have gone to the city will not come back, except in rare cases. They are lost to the race and to the future. But those with stronger instincts of life are resisting the social and economic pressure, and remaining in the country. For these the ideals and institutions of rural life must be developed, that will give us eventually an immunity to the city, so that our race may be maintained.

Diversified activities and interests are essential to human development and well-being. It is no true division of labor to keep a man doing endlessly the same thing, but only slavery made worse. Let the machines do all the work that will liberate men for other activities and satisfactions of life. Work-shops and factories are now being placed in the country, where

they may enrich the life of the farm instead of depleting and destroying it. Division of labor does not justfy parasitism, any more than it justifies slavery. Everybody should wish to do his own share of work, and with his own hands. Labor is no curse that was laid on man as a punishment, but a great pleasure and satisfaction, to do anything well. "There is no sweeter solace in life for human ills than craftmanship." Living in a house means more to a man who can build one. "Shall we forever resign the pleasures of construction to the carpenter?"

Farm labor is spared by the use of machinery and power. A man cultivates 35 acres now to 12 acres in 1850. Half of the workers in the country were engaged in agriculture in 1850, but now only a quarter. The use of electricity on farms is estimated at fifty million horse-power. The net result is that the competent operating producers not only are just as busy as those of former generations, but busy in more ways and with more of their time intensively occupied. The problem of more leisure in the country needs to be faced, as it is only under the conditions of family life in the country that leisure can be used to the best satisfaction and advantage to the race. In the words of an urban visitor, "The people in the country are too busy to enjoy it." The farm problem, after all, is the general human problem, how people are to live to the best advantage of the race, not how the farm producers can be parasitized to the greatest extent by the city. The city is only incidental to the life of the race. The farmers are producing for themselves and for the farmers of other regions, or for the artizans who make the tools and equipment of the farm. The urban rake-off that supports the millions of superfluous people in cities is no part or purpose of the farmer, but imposed by the commercial system. Excess of urban population is a burden in time of peace and a definite liability in war. The machines should help us live in the country, not drive us out.

Urban Decay of Judgment

A decay of practical judgment is to be observed under urban conditions, and especially among those who live as parasites dependent on the services of others. The natural ability of people in the city should average higher than in the country, because the urban inducements attract the more capable, but ability is not maintained or developed higher in the city. This is another biological fact that forbids us to build our hopes for the future of our race on urban foundations, or to look forward to any complete understanding of the country by the city. The life of the city is not rooted in reality to the extent that is necessary for the fruit of human intelligence to reach its full growth and flavor. Some mental vitamin of normal outdoor humanity must be lacking in a sheltered existence. Very few writers seem to have reflected on this deficiency, as most of our literature is an urban product, but Thoreau was an outdoor thinker and has brought the issue of practical intelligence to expression in a notable paragraph.

> Nothing is so difficult as to help a friend in matters which do not require the aid of friendship, but only a cheap and trivial service, if your friendship wants the basis of a thorough practical acquaintance. I stand in the friendliest relation, on social and spiritual grounds, to one who does not perceive what practical skill I have, but when he seeks my assistance in such matters, is wholly ignorant of that one whom he deals with; does not use my skill, which in such matters is much greater than his, but only my hands. I know another who, on the contrary, is remarkable for his discrimination in this respect; who knows how to make use of the talents of others when he does not possess the same; knows when not to look after or oversee, and stops short at his man. It is a rare pleasure to serve him, which all laborers know. I am not a little pained by the other kind of treatment. It is as if, after the friendliest and most ennobling intercourse, your friend should use you as a hammer and drive a nail with your head, all in good faith; notwithstanding that you are a tolerable carpenter, as well as his good friend, and would use a

hammer cheerfully in his service. This want of perception is a defect which all the virtues of the heart cannot supply.

> "The Good now can we trust?
> Only the Wise are just. . . .
> The Good they know and love,
> But are not known again
> By those of lesser ken."

Ability without character is a misfortune, but ability and character without practical judgment may do even greater harm in the world. Good men can lead us further on wrong courses, like Plato or Tolstoy. Using great talents to establish absolute beliefs does not enlighten the human mind but keeps it longer in bondage. Thinking is not higher for being apart from facts. Plato inspired a false confidence in mental processes and abstractions, that led to centuries of barren philosophy, while Tolstoy's writings weakened confidence in orderly human progress and slanted the world toward revolution. "What is earnest is not always true; on the contrary, error is often more earnest than truth." Sentiments must not envoke "principles" in order to disregard facts. Scientific knowledge is not established by argument or by weight of opinion, but on verified observation of fact.

The doctrine of scientific responsibility is to see facts as clearly as possible, in order to apply our judgment to actual conditions, and then to remain aware that even our best reckoning may not include all of the facts or foresee all of the possible relations. "No method nor discipline can supersede the necessity of being forever on the alert." Practical, adaptive intelligence comes from the hand as well as from the head. It is found more often among farm people, and tends to disappear under urban conditions. Manual exercise is prescribed for opening dull minds and advancing backward races, and is not less essential for the highest attainments. America may boast the most intelligent farmers in the world, doing their own work with their own hands and furnishing the constructive ingenuity that is the special character of our national development. The urban worker usually has only one task or responsibility before him, but the farmer must use judgment continuously to adjust the demands of many conflicting tasks. Farming is a complex of many manual arts and knowledge of many facts, including the characters, behavior and requirements of the different kinds of plants and animals.

From the city viewpoint farming looks hopeless enough, with its dozens of different things to be done, each one of which would be considered in the city as a separate trade or profession. Also the country does not respect the urban conventions that separate the different occupations of the city from each other and set them apart from the home and family responsibility.

> It is a great disadvantage in country life that a farmer is expected to do so many different things; he has not only to grow crops and raise stock (two separate arts to begin with, and difficult ones, too), but to be a man of business, keeping complicated accounts and selling his crops and cattle, which is a different sort of job, needing a different sort of man. And, as if this were not enough, he has to keep his dwelling house as part of his business; so that he is expected to be a professional man, a man of business, and a sort of country gentleman all at once; and the consequence is that farming is all a muddle; the good farmer is poor because he is a bad man of business; the good man of business is poor because he is a bad farmer; and both of them are often bad husbands because their work is not separate from their home, and they bring all their worries into the house with them instead of locking them up in a city office and thinking no more about them until they go back there next morning.*

It is true that the good urban husband has his work cut out, and needs no other distractions while he is trying to perform in that capacity. Raising a wife and children as household pets may prove as intricate and exacting as the whole complex of farm re-

*Geoge Bernard Shaw, quoted from *The Field* (London) for June 28, 1928.

sponsibilities. But children may be going into more trouble than Shaw intended. It is a vice of the city, not a virtue, that it separates the family from the contacts and responsibilities of life.

Urbanized people have no inkling of the interest of farm accomplishments or even of the physical satisfactions of out-door life and hard work. Farmers are considered very stupid to endure the rural privations, instead of moving to the city. Even the best urbanites are accustomed to despise the farmers, and in turn are distrusted for their lack of farm sense. The farmer knows very well that he is working harder, taking more chances, and receiving a smaller return, than his cousin in the city. The note of blame may be heard on either side. "For if the countryman is profoundly convinced of his moral superiority over the townsman, the townsman is just as profoundly convinced of his intellectual superiority over the rustic." The urban attitude of condescension appears selfish and unjust to the farmer, but is only the natural effect of limited experience and understanding. Mutual interest and appreciation are necessary for practical cooperation and respect. We need not be impatient of solving all of our problems at once, but the practical ability of the race must not be sacrified to the urban propensity.

The discovery that farmers may be men of the highest ability and intelligence has been demonstrated in our national history in thousands of examples, but the racial significance of the fact has not been appreciated, nor the need of maintaining rural ability and intelligence as the basis of national progress. Rural schools and education have been urged and to a certain extent supplied, but not in ways that have served to develop the race or to maintain the standards of intelligence. The people in the country, with farm and family responsibilities, have full and absorbing lives, "for the sweets of marriage and the dearness of children draw men from performing great and lofty services of the commonwealth; being content to be perpetuated in their race and stock, and not in their deeds." Thus the country tends to be silent, while the towns and cities are vocal, and are heard for their much speaking. The currents of life and thought have flowed to the city without the danger being seen that these tendencies, working through adverse selection, would deplete the race, subvert agriculture and destroy civilization.

Farm Life Indispensable

To live as a parasite is to become dependent on others. The human breed does not prosper in urban captivity. Even the most intelligent and right-minded people deteriorate in the city. With life reduced to a narrow urban routine, it is inevitable that we become helpless and inept in a few generations. Living in the city is easier—but it is not living. The instinct of self-preservation should teach us not to become parasites. If ability and intelligence are to be maintained and increased in the future generations of our race, the farm conditions are necessary. Our social ideals and economic relations must be so adjusted that the more capable members of the race may remain in the country and raise families, instead of being drafted to the city to be eliminated.

The physical disadvantages of cities to a great extent have been removed by sanitation, pure food and athletics, but there is no complete exercise of the human faculties apart from the world of nature. Organs and instincts that are not used are not fully developed and eventually are lost. This is a principle of social relations, as well as a phenomenon of plant and animal life. Many forms of degeneration are shown in the various parasitic groups. The gradual decay and debasement of royal houses, aristocracies

and dominant classes is repeated in the histories of many countries, and the same tendencies are shown in cities, through luxury and over-refinement, where dissipation and idleness are avoided. The people who live the sheltered lives even come to despise those who do the farming or other necessary work, thus showing a perversion of moral judgment as well as a loss of practical ability.

Our notions of what is normal and desirable in life must look to the future. Not to be interested in the future is a mark of degeneracy, a lack of normal parental instincts. Nobody would tolerate the idea that any child should be raised on a pavement, if our minds were not perverted by the city. Ideas and ideals must be adjusted so that we may be conscious and ready for the right things in life, those that are in line with a normal development of the individual and the continued reproduction of the race. "That man is in the right who is most closely in league with the future." Our deepest and best sentiments of patriotism, gratitude, and veneration of the past, intensify our interest in the future. Conservation of farm people must be considered as well as of forest trees and soil fertility, to keep a good world for coming generations. People who wish to remain on earth had better stay on the farm.

Thoreau and Burroughs may be reckoned as eminent specialists in observing the reactions of people to the environment of nature. The facts that they recognize forbid us to hope for a higher development of the practical ability and intelligence of the race under urban conditions, or with the farm population restricted to the less capable members of each generation, as the tendency now is. Not to preserve and develop the ability that we have is a cardinal sin, for a nation as for an individual—a sin against our human nature. The experience of history does not indicate that there is any way to maintain a great nation after ability is depleted. What a nation does not sow it shall certainly not reap.

A new independence of thought and action must be developed among farmers, a conscious life and purpose not so narrowly individual as in the past, but with a more definite appreciation of the values of out-door life and of the family and community relations, as superior to any urban conditions. The community life is as real as the home life, from the standpoint of eugenics, and is the next stage to be recognized in the development of rural institutions. It is only by deliberate purpose and effort that the present dominance of urban ideas is to be escaped and counteracted. A real farm literature must be made, and by farmers themselves, because urbanized authors can not write it. Many books on agriculture are written with good intentions, but from urban standpoints. The artificial standards of the city are tacitly accepted and the natural and deeply instinctive satisfactions of rural life are not recognized, or are left without adequate expression.

Some of the farm satisfactions are recounted in the final chapter of *These Changing Times*, under a rather dubious title, "Can A Farmer Be Happy?" Cautious advice is given to those who are facing the question whether they should be farmers or not, to help them to judge whether they will be satisfied with what farming can give them. A greater need should be voiced, for farmers who are not to be satisfied with the present status of farming, but are resolved to claim their birthright of a normal human life for themselves and their children. Our right to live in the country must be exercised and protected. It is the form of liberty that is the most important to preserve. The farm problems are not be solved by moving to the city. "The future of a nation with a democratic government depends not only upon the intelligence and general knowledge of its citizens, but upon the desire and purpose of those citi-

zens to make national life what it should be." Many of the farm apostles have not recognized the human elements of the farm problem.

Every intelligent and right-minded boy should be brought up to see the possibilities of a larger life on the farm, and that more may be done for the race and nation by developing the farm life than by any success in the city. The highest forms of constructive ability are needed, instead of being sacrificed to the city. Those who remain in the country should know what agriculture means to the life of the race, and should have the satisfactions that a truer appreciation of their own lives and possibilities of development would give them.

The farm questions can be argued at any length without being understood, and even without recognizing the principal factors, as in a recent book called *Urbanization,* by John Griffin Thompson. Too much isolation in the country and too much congestion in the city are alike deplorable. The problem is not to choose between the two evils, but to find the condition where human development is best assured for the individual and the race. Checking over the birthplaces of a few prominent men is not a way of determining the effects of rural or urban conditions. "I see no sort of evidence that a dull man is converted into an intellectual or moral giant by contact with the soil. But neither do I believe that any such process results from his contact with asphalt and concrete."*

Whether a man was born in the country or in town may make much less difference in his development of practical ability than where his parents or grandparents were born, with whom his childhood and youth may be passed, and his mental habits formed. The menace of the city is not recognized because people do not change suddenly or consciously as they pass to urban conditions, which they meet as a new experience, with no judgment of its general tendencies. Most of the Americans who live in cities have come from the country and many urban families maintain their rural contacts and mental habits for several generations. If the proportion of capable people from the country is less than formerly, as statistics from *Who's Who* are said to show, depletion of the country would be indicated, rather than an advantage of town conditions for the race. Ability is always being recruited from the country because it is not maintained and multiplied in the city.

As long as we take it for granted that the bright boys and girls in each generation are to be sent away and educated for careers in the city, adverse selection will go on depleting the country of its natural leadership and reducing the ability of the race. Probably no race in the past has been subjected to such general and intensive selection as is now being applied to the farm population of the United States through the system of popular education, combined with the social and economic pressure to the city. Practically the entire product of our system of higher education is supplied to the city to be eliminated, instead of being established in the country, that the race may continue and not deteriorate.

Statistics have shown that graduates of higher institutions are not raising enough children to keep up the student body, and the rest of the well-to-do urban population probably is not more prolific. The "upper crust" is a poor soil. Working families in the city have better chances than the rich to make contacts with life, but the "social ladder" of "higher education" is at every door. Six times as many students are reported to be in our colleges as 30 years ago, though population has scarcely doubled, and that largely by immigration. Thus the rate of adverse selection among

*Johnson, Gerald W. The Rise of the Cities, *Harpers Magazine,* July, 1928, pp. 246-250.

native-born Americans may be several times as great as in former generations. Our best intentions are played against us through our blind confidence in schools, which are trying to teach us books but do not teach us life. Urban ideas are dominant in education, and are accelerating rural depletion. Even the most elemental and self-evident facts, as the need of parental contacts and farm conditions for children, are being obscured and disregarded. It is time for a constructive interest in agriculture that shall take account of the racial and educational values of farm life.

Subsidizing the Surplus

The *New York Times* of October 24, 1928, reported a conference of the New York Food Marketing Research Council, in which several speakers recognized that an injurious over-production is being induced by loans from the city. Objection was taken especially to advances on crops by commission merchants, which often are furnished without interest and without security. Obviously, such operations are strictly speculative and are a form of very unfair competition with legitimate farming, since responsible producers are required to pay interest and to give security for loans. The practice was condemned at the New York conference "as having caused over-production of inferior products, enabled unscrupulous and unqualified growers to remain in the industry, brought about undue accumulation of supplies in certain markets, with a consequent disparity in prices, and resulted in numerous bankruptcies which had a bad effect on the trade."

A resolution was adopted by the conference, that the "need for further studies along this line should be emphasized and brought to the attention of public and other research agencies." It is plain enough that the crop loans are directly to the prejudice of the secured loans; virtually the crop-loaner is being subsidized to destroy the farmer. That this should go so long unrecognized is a further indication that the farm problems are being viewed casually, and mostly from urban standpoints. The city pours its millions into subsidizing the surplus while nobody sees what this does to the farmers.

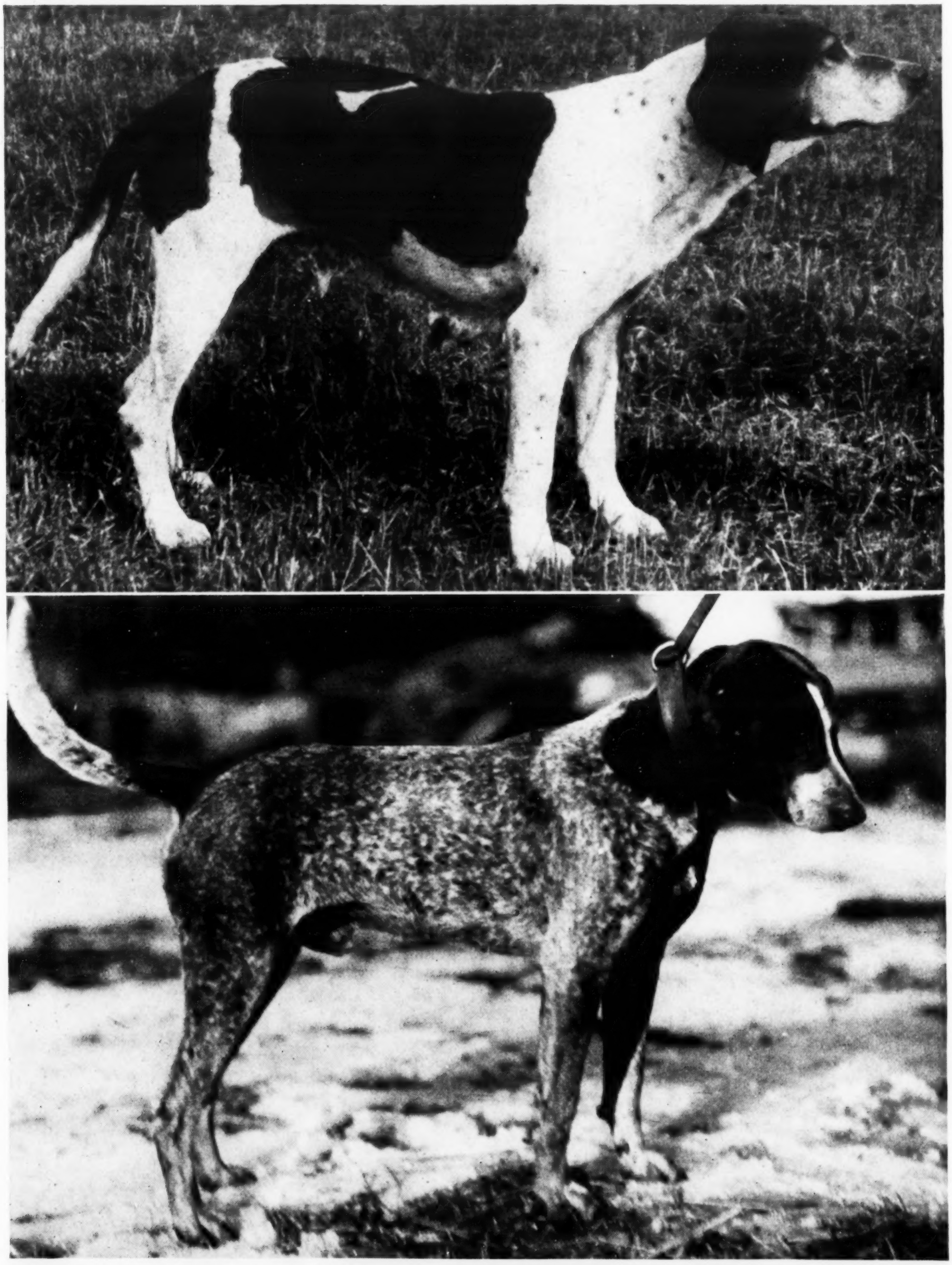
A Handbook of Tropical Crops

THE TROPICAL CROPS, *by* OTIS W. BARRETT, Agricultural Director, Department of Agriculture and Labor of Porto Rico. 445 pp., 24 plates. Price, $4.00. Macmillan Co., N. Y. 1928.

An excellent addition to our limited library of American books dealing with tropical agriculture, Mr. Barrett draws on a wide tropical experience gained from thirty-five years spent in tropical countries, such as Mexico, Africa, the Philippines, and the West Indies. The book gives both a popular and scientific treatment to the vast array of tropical crops. It touches on the more important phases as regards characteristics, important commercial possibilities, and cultural methods in use in various parts of the tropical world.

The early chapters discuss clearly and concisely the general nature of climate, geography, living conditions, labor and field practices encountered throughout the world's great tropical areas. The rapid strides in present-day tropical colonization and development have been made possible through advanced knowledge of sanitation, improved cultural practices, and the adoption of modern machinery. Succeeding chapters treat with each of the important tropical crops, such as coffee, cocoa, tea, sugar cane, citrus fruits, the banana, cocoanut, and rubber, and minor crops.

J. P. G.



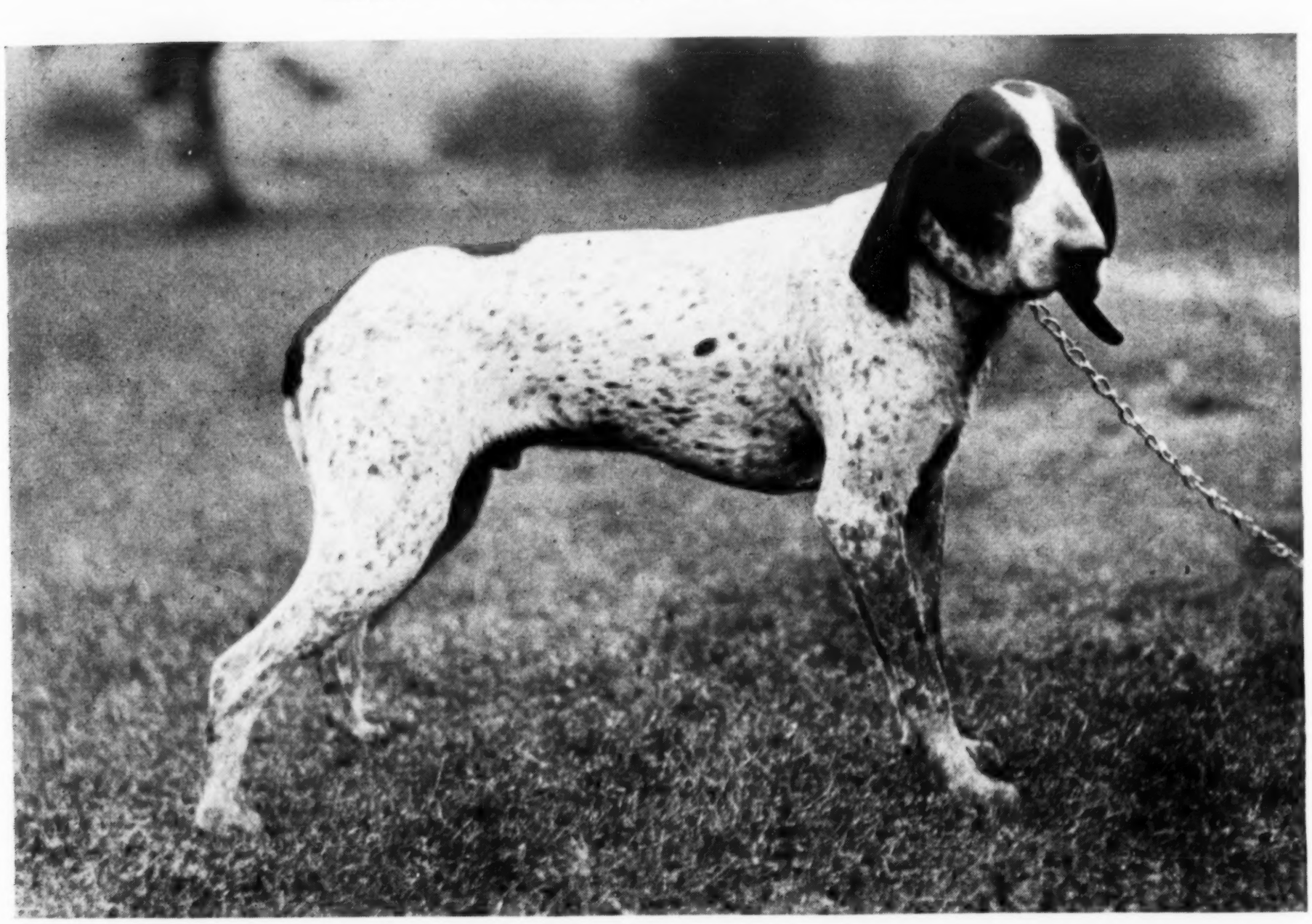
SPOTTING AND TICKING—TWO DISTINCT CHARACTERS

Figure 3

Spotting, shown in the upper picture, is distinct from ticking, shown below. Ticking resembles the roaning of cattle, but differs from it genetically, as roaning is supposed to the heterozygous condition of certain spotting factors, while ticking behaves as a simple dominant. In matings of the two dogs shown here, eight out of fifteen pups were ticked.

THE INHERITANCE OF A TICKING FACTOR IN HOUNDS

LEON F. WHITNEY, *New Haven, Conn.*



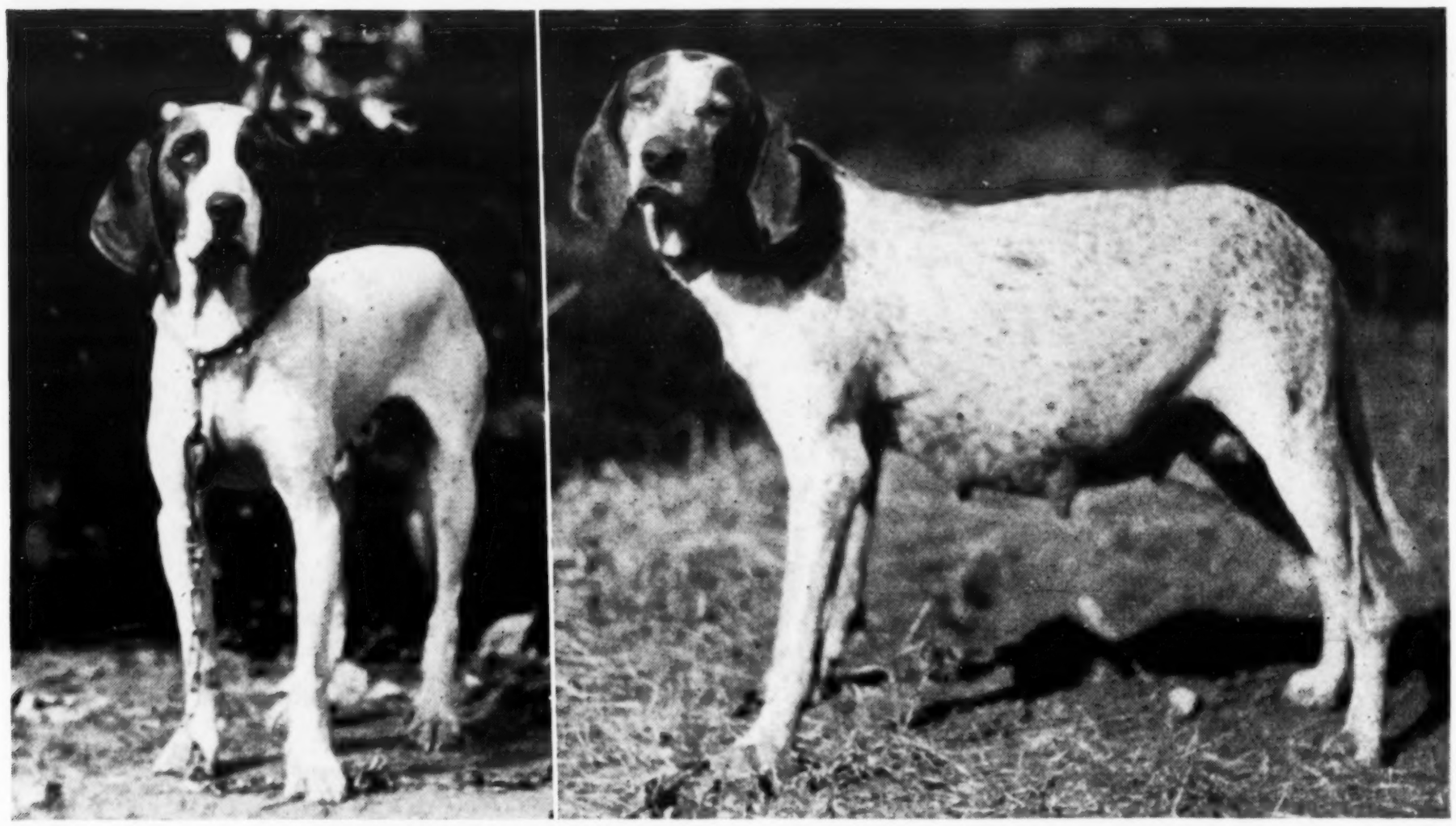
A FAMOUS TICKED SIRE

Figure 4

About half his progeny was ticked, indicating the dominant nature of the ticking factor.

COLOR inheritance in hounds has been studied by many persons. Galton began the work. Hagedoorn in 1912, Allen in 1914, Ibsen in 1916 and Wright in 1918 deal with the question. It is not the object of the present paper to deal with all of the phases of coat color, but to attempt to show the existence of one Mendelian factor which has hitherto not been studied. In a subsequent paper it is proposed to use the information from this, as an aid in studying more fully the inheritance of coat color in hounds and breeds related in these particulars.

A brief description of coat color here will be necessary, however. Bloodhounds and dachshunds are usually black and tan in color; that is, they are tan with a black saddle, and sometimes white on the extremities and chest. Foxhounds are colored the same, but often have the white extended. It may cover only the legs, chest, tail, and a blaze in the face, or it may completely cover the dog so it appears entirely white. Again it may be imperfect, so to speak, and large patches of the black or tan may appear. These patches are quite distinct as is shown by the dog in figure I. Beside these colors hounds are also black-and-white and tan-and-white (the tan of various shades). Also there are self tans and self blacks.



PARENTS OF THE PUPS SHOWN OPPOSITE

Figure 5

A spotted sire and a ticked dam produce spotted and ticked pups, as shown in figures 6 and 7.

Wright in the JOURNAL OF HEREDITY, 1918, notes that sometimes a roaning is present in cocker spaniels. He has called this *R*. No attempt has been made to study its inheritance. This roaning, which appears in other breeds as well as cocker spaniels, is the subject of this paper.

In appearance some animals with this character look much like roan shorthorn cattle. There is, however, considerable variation. Some dogs appear as light as the dog shown in Figure 4 up to a heavily speckled condition such as that shown in Figure 3. The effect is produced by small groups of pigmented hairs liberally scattered about the white.

It would seem that the term *roan* is not the proper one to use in describing this phenomenon because of the likelihood of confusing it with the kind of roaning in cattle, as it is hoped the following data amply prove. In cattle, roaning is the heterozygous condition between the white and the red. In dogs, as we shall see, it behaves differently.

Dog fanciers refer to dogs with this color character as *ticking*. This nicely describes the condition and is so commonly used that it would seem well to continue, and in stead of *R* to substitute the initial *T*.

The following general facts are of interest: There are certain strains of setters which breed true, and fanciers rely upon this ticking character to differentiate them from other strains. One strain is called "Blue Belton." The fact that the setter has long hair causes the black or tan from the tiny ticked areas to mix with the white and cause a blue appearance. Pure blue beltons produce 100 per cent ticked pups.

Another strain of setters is orange ticked. These have no factor for black and therefore exhibit tan hairs.

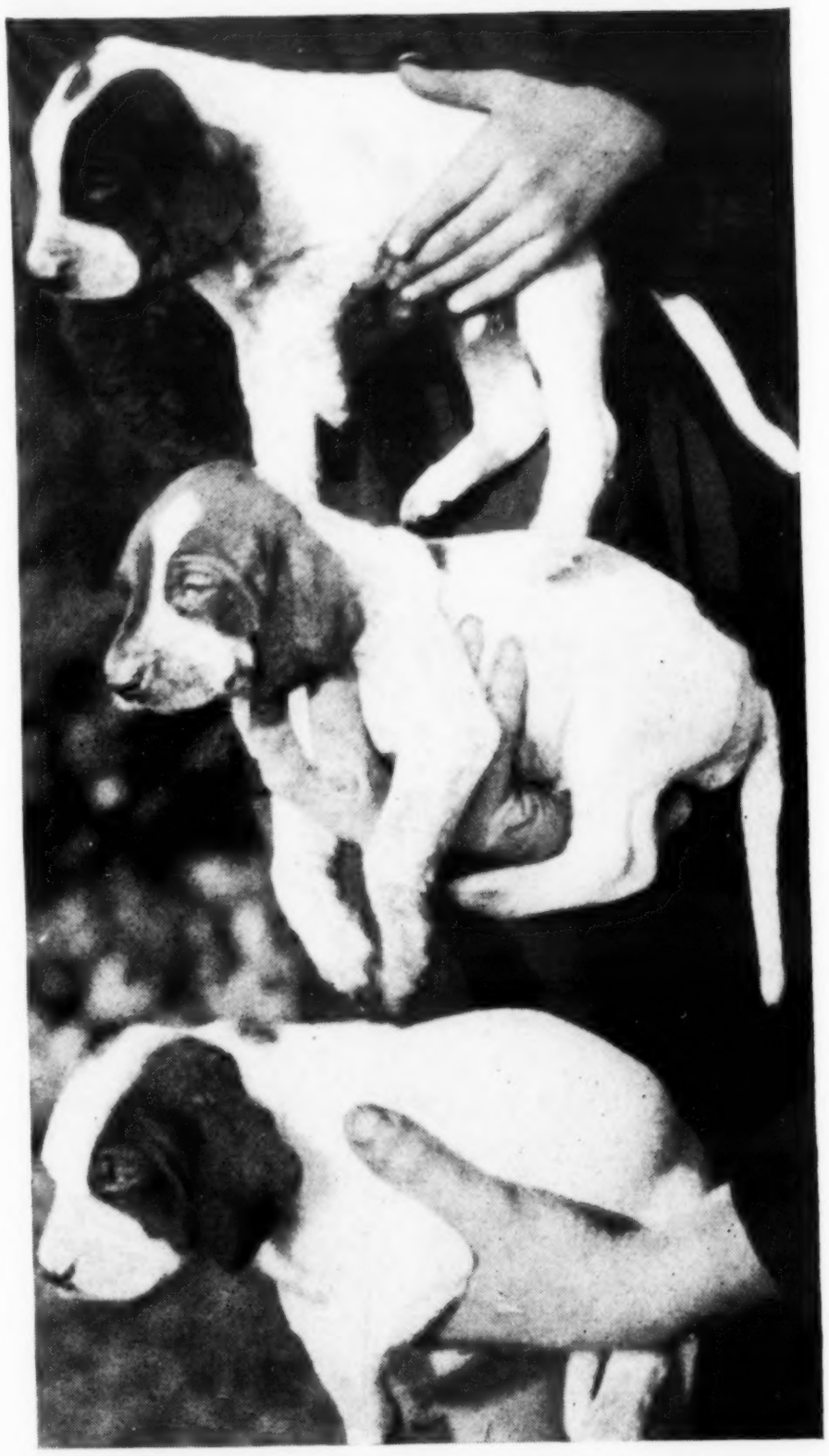
One strain of foxhounds, known as the *Bluctick* strain, breeds true from many representatives of the strain.

Thus it will be seen that the condition may be homozygous and is thus different from the heterozygous roaning of shorthorn cattle.

SPOTTED×TICKED PROGENY

Figure 6

Pups of three colors were produced. Ticking was not restricted to black, tan ticking being seen in tan-spotted dogs.



THREE COLOR COMBINATIONS

Figure 7

Three of the pups from the litter shown in Figure 6 showing the color combinations resulting from this mating: Black, tan, white, and ticked (at top); tan and white, ticked; and tan and white, with no ticking.

An equally important consideration is that no pair of dogs of white color has been known to produce a ticked puppy.

What led the author to suspect that the ticking was a simple Mendelian trait was the many litters of pups sired by the male in Figure 4. He was a famous hunting dog (trained on raccoon). Hunters brought many bitches of all colors to be bred to him. Usually about one-half of each litter was ticked unless there were black and tans or solid colors present. Even among these, where they showed white on the

chest, some would be found with the white spots ticked.

Another interesting fact is that the ticking does not appear at birth, but begins to show at about four weeks of age, usually.

In order to determine whether or not the character is a simple Mendelian, an examination of records and special matings shows the following:

When the pair of dogs shown in Figure 3 was mated, of two litters of pups (15 in all), eight were ticked. The parents were both tri-colored, the father was ticked, the mother not.

When the dogs in Figure 5 were mated the litter of pups shown in Figure 6 was produced. Figure 7 gives a close-up of the three colors of pups produced. Many other like instances could be cited.

When the ticked male in Figure 3 was mated to his sister, shown in Figure 5, two pups out of seven were tri-colored; the rest were ticked and tri-colored.

Whether or not the more perfect spotting of the Dalmatian is a variation of the ticking remains to be proved. That it behaves as does the ticking is testified in several instances. One, an authentic cross made by Mr. Franklin J. Willock of Syossett, L. I., of a pointer and a Dalmatian produced a litter all of which were spotted like Dalmatians.

It should be noted that the ticking applies only to the white. In case of black and tan dogs, the ticking does not affect the black so that tan ticking appears in it. It is interesting to note that the ticking is often carried by self-colored or black-and-tan dogs, and yet is determinable only by breeding despite the fact that conclusions show it to be a dominant.

One of the most important considerations as regards ticking is that it reveals the true genetic color composition of the dog. Thus, if a dog would normally appear to have tan ears, a black spot or two on the body and all the rest white, if he is also ticked he will be seen to have a perfect black and tan pattern, because wherever the dog would normally be tan, the ticking is tan; where the black saddle would be, the ticking will be black.

It seems, therefore, reasonable to conclude, in view of the preceding statements, that ticking is determined by a Mendelian factor *T*, which behaves as a simple dominant, that it must be associated with white and does not affect other colors.

GENEALOGICAL CORRELATIONS OF STUDENT ABILITY

HOWARD J. BANKER

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IT has long been recognized that members of the same family show similarities in mental traits and reactions as they do in their morphological characters. While it is generally believed that these psychological resemblances and variations are subject to similar biological laws with the morphological and physiological variations in plants and animals, it has been difficult to obtain a satisfactory demonstration. The study of these traits, peculiar to the human being, is not only hampered by the complexity of the organism and the intangible character of the reactions involved, but even more serious is the difficulty of comparing such subtle traits from generation to generation over the long periods of time necessary. With the development of methods of measuring the so-called "intelligence" of individuals by means of mental tests, some definite progress has been made in the possibility of measuring the mental characteristics of different persons. To a certain extent brothers may be compared in mentality with brothers, with sisters or with non-sibs, but the more important problem of comparing children with parents and grandparents or more distant relatives cannot be approached by these methods, because of the difficulty of obtaining any co-ordinated data on which to base these comparisons.

The obvious suggestion that the school records of children for several generations could be used has generally been discredited and abandoned as utterly inadequate for two very serious reasons. First, the lack of uniform records and often of any at all as to the accomplishments of children in a school covering a period of more than one generation renders the method impracticable in most cases. Of the few schools that have had a continuous existence for a sufficient length of time, still fewer, owing to the shifting of population, have served to educate the parents much less the grandparents of the present generation and scarcely a school has preserved its records for a generation of time. Second, even if records were to be found, it seems obvious on *a priori* grounds that the great changes in the progress of educational methods would render them utterly incomparable. It must be observed, however, that educational changes have been more rapid academically than in practice. The writer well recalls the spell-binders of teachers' institutes forty years ago "kicking the text-books out of the windows" while the teachers and school boards as regularly brought them back through the door. Yet changes have occurred, but whether sufficient to make void all comparison of school accomplishment of today with that of yesterday must be determined by practical methods. A more serious objection appears to be the demonstrated unreliability of teachers' marks under all circumstances as a measure of the child's accomplishment in his school work.[1]

Admitting much truth in these objections, it is obvious that a comparison of the ability of the children of successive generations to meet the educational requirements of the school curriculum is the most natural basis for determining the relative mental ability at like age for parent and child. As there appears to be no other available means for comparison, it has seemed to be desirable that the possibilities in-

volved in school records should be exhaustively investigated before they are completely discarded.

Three Generations of School Records

It was the writer's rare fortune to come in contact with the one school situation which seemed to overcome in a remarkable degree many of the difficulties in the use of school records. The institution itself had been subject to state administration continuously for more than sixty-five years, during which time both an elementary and a high-school organization had been maintained, providing twelve years of continuous educational instruction, beginning normally at the age of six years. The school records during this long period had been preserved nearly intact and furnished not only the name, parentage, approximate age and attendance of each student, but also his progress from year to year through the departments and in most cases a teacher's mark, usually on a percentile scale, of his work in each subject per term both in the high-school and in the four advanced years of the elementary work.

This school was located in a long settled and unusually stable community. The ancestry of a large proportion of the students could be traced back in several lines for more than 200 years in the same locality. Naturally there were many interlacing lines of relationship due to intermarriage, but the community could not be called in biological parlance especially closely inbred. The teachers were in some instances as stable as the community. The superintendent has been head of the institution for twenty-three years, and several teachers have given instruction to two and in some cases to three generations of the same family. Before the present school system was organized, elementary and advanced educational facilities were amply provided by public elementary schools and an old style Academy founded shortly after the Revolution, so that a uniform educational environment has existed from generation to generation long prior to the present regime. The records of the older organization are not known to exist.

Here then was a challenging situation, the only seriously questionable factor in the available data was that of the reliability of the records as a means of classifying the students in respect to their relative ability to meet the educational demand upon their mentality. It has quite generally been accepted and is believed by many to have been demonstrated that teachers' records do not furnish a reliable index of student accomplishment or of mental ability. In spite of this fact, the force of which must be fully admitted, the situation seemed to demand that an attempt should be made to make the most complete use possible of these amazing records under such unique conditions.

The Student's Ability Index

The first problem was to find the most efficient index that could be derived from such records. Without regard, therefore, to the demonstrations of the unreliability in school marks generally, the attempt was made to develop as reliable an index as possible for this school based on the student's progress through the school curriculum combined with the teacher's mark as to his success in meeting the requirements from day to day. For the full development of this index, called the SAI or Student's Ability Index, and the demonstration of its degree of reliability under given conditions reference should be had to previous papers by the author.[2] The present paper is confined to a study of the distribution and relation of the indicated qualities or traits in the members of a family. The SAI in numerical value and distribution is the equivalent of an intelligence quotient (IQ).

A Student's Ability Index* was computed for as many students as possible in the five advanced years of the elementary school only, equivalent to Grades IV. to VIII. inclusive, and having genealogical relationship one with another.

In computing the index from this formula, aside from the inaccuracy of teacher's marks, there were two other sources of error that might seriously affect the value of the student's index. The first was inaccuracy in the birthdate. Every possible effort was made to assure accuracy by consulting the town records, church records, family records, burial records and inquiring of individuals as to their own birthdates. No one of these sources can be regarded as absolutely correct, but taken together, they serve to check one another and few errors escape detection. The second source of error is due to the fact that in the earlier records of the school the course was divided into larger units of progress than the present half-year grades. If a student's progress or attendance were irregular it was sometimes difficult to determine accurately his corresponding place in the curriculum of the present and this might affect seriously the computation of the SAI. If this error was large and could not be corrected the data were rejected. In most cases, however, the average place of the student over two or more semesters gave the same index as his true position in each semester.

Evidence of Inherited Mental Ability

As the preliminary work would be a test of the practicability of the index as well as furnishing evidence of correlations, it was desirable to insure, as far as possible, the elimination of all sources of error. For this reason all data that showed not only obvious errors but that in the opinion of the worker appeared suspicious, were discarded although open to the objection of the effect of a personal equation. After such selection, thirty-eight families were obtained in which the index could be computed for both parents and for one or more children, giving a total of eighty-three children. Calling the average SAI of the two parents in each family the SAI of the mid-parent the correlation between the SAI's of the mid-parents and of the children was computed by the Pearson method of moments for ungrouped data. In families of more than one child the mid-parent SAI was paired successively with each child so that the mid-parental SAI was repeated as many times in the correlation table as there were children in each family. This gave 83 pairs of SAI's. The coefficient of correlation, or r, obtained was:

$$r = .4999 \pm .0555$$

The correlation was positive and statistically significant, the coefficient being practically .5 and nearly ten times its probable error.

As a basis for the computation of an SAI was very complex, involving many unknown factors, it became a question whether the correlation obtained was in some degree due to factors not specifically inherent in the parent-child relationship. To test this matter a correlation table was worked out precisely as before but for the SAI's of mid-parents and non-children, that is, the mid-parents were paired not with their own children but with the children of the next succeeding family in the list. In this way the correlation was based on exactly the same parents and children as before only differently arranged so as to break up the genealogical relationships. Again there were

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*From the formula: $$*SAI = \frac{Mk}{CA} \times \frac{MGA}{GMk}$$

In this formula MK=the individual student's average mark; CA=the chronological age of the same student; MGA=the standard average mental age for students in the grade in which the student is working; GMK=the standard average mark for students in the grade.

83 pairs of SAI's and a coefficient was obtained:

$$r = -.1172 \pm .0730$$

Since this r was less than twice its probable error, it did not significantly depart from zero and the fact that it was negative meant nothing. Hence, we conclude that as tested by statistical criteria the correlation of the SAI's of mid-parents and children is positive and significant, and under the same circumstances there is essentially no correlation between mid-parents and non-related children. Therefore, the SAI appears to measure with a significant degree of accuracy something inherent in the parent-child relationship.

Encouraged by this result, an attempt was made to determine the correlation of the SAI in the case of other genealogical relationships. Satisfied that we had demonstrated a high degree of reliability in this index, less rigid restrictions were employed in the selection of data, but cases involving obvious error were rejected. The correlations were not confined to families having two recorded parents, but any families supplying suitable individuals for pairing in the different tables were employed. This enabled us to utilize families previously excluded and permitted larger numbers than would otherwise be possible. The fact that some of the correlations have fewer pairs than in the correlation of mid-parents and children is due to the fact that in the latter case the sexes were not separated. As before the parents are repeated in pairing as often as there are children that meet the conditions and in the fraternal correlations each sib is paired with each of the other sibs as required making in some cases more pairs than actual individuals.

In this manner correlation tables were prepared for various genealogical relationships such as father with mother for assortative mating, father with son and with daughter, mother with son and with daughter, brother with brothers and with sisters and sisters with sisters. In many cases, as a check, the correlations of individuals with unrelated individuals of the same category were computed. In these cases precisely the same individuals were used as in the corresponding table of related individuals only so paired as to break up the genealogical relationships. That is, the father is now paired with the mother of the next family of children instead of with the mother of his own children. Likewise father, or mother, is paired with the next parent's children and not with his own.

We have tabulated a summary of all these tables, giving in each case the mean SAI and the standard deviation for the distribution of each member of the paired types as well as the coefficient of correlation.* For comparison we have furnished the coefficients obtained by Professor Karl Pierson and Miss Alice Lee[3] in correlation studies of the physical measurements of humans having like genealogical relationships. No one will question the possibility of making physical measurements with a high degree of accuracy. The similarity of results in most instances is surprising.

Space will not permit a discussion of the questions that arise from this work. We will leave that for the reader according to his interest. The writer's purpose has been only to demonstrate by a practical test the significance of the SAI as an index in scientific research. The number of our families is too few for satisfactory statistical treatment. The exclusion of a single erratic family in the table of correlation of sisters with sisters would raise that coefficient from .138 as given in the table to .281. We cannot, there-

*The coefficients of correlation or r's were computed from the ungrouped data by the method suggested by J. Arthur Harris in his paper on "The Arithmetic of the Product Moment Method of Calculating the Coefficient of Correlation." *American Naturalist*, 44: 693-699. November, 1910.

fore, lay much stress on these figures.

Nevertheless, we seem to be justified in concluding that:

I. Th student's ability index measures a complex of personal reactions with a high degree of efficiency, apparently nearly as efficient as the measure of a person's height with a yardstick.

II. It may be assumed that one of the chief factors in these reactions is the inherent intellectual capacity of the individual.

III. The complex measured is a function of the genealogical relationships of the individuals as much as any measurable physical characteristic.

In every relationship except that of sister with sister there is an appreciable positive correlation, and in every case where the same individuals are paired in non-relationship there is essentially no correlation.

TABLE I—Distribution and correlation of the SAI's of genealogically related students, based on the school records of the five highest elementary grades, IV-VIII, with correlations of physical measurements for comparison.

Genealogical type of student	No. of pairs	Mean SAI	Standard Deviation	Coefficient of Correlation	Pearson and Lee on Human Stature	
					Pairs	Coefficient
Fathers and Mothers	45	95.8 ± 1.53 100.4 ± 1.20	15.18 ± 1.08 11.98 ± .85	.239 ± .095	1079	.280 ± .019
Fathers and non-mothers	45	95.8 ± 1.53 100.4 ± 1.20	15.18 ± 1.08 11.98 ± .85	.088 ± .100		
Fathers and sons	56	97.1 ± 1.33 100.1 ± 1.29	14.75 ± .94 14.32 ± .91	.517 ± .066	1078	.514 ± .015
Fathers and non-sons	56	97.9 ± 1.41 100.1 ± 1.29	15.60 ± .99 14.32 ± .91	.038 ± .090		
Fathers and daughters	60	98.8 ± 1.16 105.6 ± .98	13.30 ± .82 11.24 ± .69	.504 ± .065	1376	.510 ± .013
Fathers and non-daus.	60	97.3 ± 1.12 105.6 ± .98	12.84 ± .79 11.24 ± .69	−.108 ± .086		
Mothers and sons	56	95.1 ± 1.21 97.0 ± 1.20	13.38 ± .85 13.33 ± .85	.448 ± .072	1057	.494 ± .016
Mothers and non-sons	56	96.6 ± 1.51 97.0 ± 1.20	16.81 ± 1.07 13.33 ± .85	−.240 ± .085		
Mothers and daughters	68	96.9 ± 1.08 105.0 ± .98	13.26 ± .77 11.93 ± .69	.361 ± .071	1375	.507 ± .014
Mothers and non-daus.	68	95.6 ± 1.11 105.0 ± .98	13.54 ± .78 11.93 ± .69	.015 ± .082		
Brother and brother	50	93.7 ± 1.35 93.8 ± 1.20	14.20 ± .96 12.58 ± .85	.660 ± .054	328	.511 ± .028
Brother and sister	136	96.0 ± .78 102.2 ± .69	13.52 ± .55 11.90 ± .49	.556 ± .040	1401	.553 ± .013
Sister and sister	84	104.1 ± .79 103.0 ± .85	10.71 ± .56 11.55 ± .60	.138 ± .072	473	.537 ± .022

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Selective Fertilization

Selective Fertilization, *by* Donald Forsha Jones, pp. 163. Price, $2.00. The University of Chicago Press. Chicago, Ill. 1928.

This little book of 163 pages, including bibliography and index, summarizes the existing knowledge of selective fertilization and the closely allied subjects of assortative mating, and sterility within and among species.

Since the author has been the chief contributor, in recent years, to the field of selective fertilization, the book is largely a compilation of his previously published material to which has been added brief reviews of the work of others. The progress of investigation since the book went to press finds certain of the chapters in need of revision—a condition the author realized was inevitable. No claim is made for the presentation of new data, but geneticists generally will welcome this slight volume which brings together the literature on a subject rapidly increasing in interest.

The only just criticism is the price ($2.00) and it seems unfortunate that some less expensive form of publication could not have been found in view of the transitory nature of many of the conclusions.

J. H. K.

Animal Genetics and X-ray Mutations

I. W. Schleip, Entwicklungsmechanic und Verenbung bei Tieren.

II. P. Hertwig, Partielle Keimesschadigungen durch Radium und Rontgenstrahlen. Handbuch der Vererbungswissenschaft, edited by E. Baur and M. Hartmann. Vol. 3, Gebrüder Borntraeger, Berlin, 1927. 83 figures. 9.60 marks.

This is the third issue of the large compendium of genetics edited by Baur and Hartmann. Two other issues were reviewed before in this Journal. The first chapter by Schleip gives an account of the mechanics and physiology of development of animals as related to genetics. Schleip gives a concise but adequate outline of the most important developmental factors concerned with differentiation and organization. We have to deal here with three principal problems and the material is arranged accordingly. That is, first, the rôle of environmental factors and their influence upon the developing egg; second. the rôle of the cytoplasm; and third, the importance of the nucleus for differentiation and determination during embryogeny. Many readers doubtless will welcome a very clear account of our knowledge concerning the centres of organization which is given with particular reference to the work of Spemann and his pupils.

P. Hertwig gives a rather complete review (and bibliography) of the experimental work concerning the influence of radium and X-rays upon embryonic development and genetic expression. In the light of recent investigations this subject should find much interest.

W. L.

HYBRIDS OF THE HAUTBOIS STRAWBERRY

Fertile Hybrids between *Fragaria Moschata* and *F. Virginiana* Indicate that the Former Species May Have Entered into Development of Modern Varieties

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ALTHOUGH the evidence[3] seems to indicate that the common cultivated strawberry is derived largely from two American species, *Fragaria chiloensis* and *F. virginiana,* its derivation from either *F. moschata* or *F. vesca,* even in part, has been questioned. The report by Duchesne[2] that the original importations of *F. chiloensis* from which cultivated strawberries apparently descended were pistillate and were probably pollinated by *F. moschata* or *F. vesca* first suggested that one or both of these species had entered into the development of cultivated varieties. Various breeders, Brinckle,[1] Van Fleet[7] and others, have since reported the use of one or both species in the origination of new sorts. Richardson[6] even noted that characteristics of *F. moschata* could be seen in some European varieties. However, Mangelsdorf[4] and East[6] have doubted that this species entered at all into cultivated sorts, especially as *F. moschata* proved to be a 21-chromosome species, whereas cultivated varieties together with *F. chiloensis* and *F. virginiana* proved to be 28-chromosome kinds. Moreover, their crosses of *F. virginiana* and *F. moschata* were sterile.

The use of both *F. moschata* and *F. vesca* in horticultural breeding is desirable for many reasons. For example, the fruit of *F. moschata* is very aromatic and highly flavored, while forms of *F. vesca* exhibit desirable everbearing habits different from those in cultivated sorts.

The writers have made considerable numbers of hybrids between *F. virginiana* and *F. moschata,* using a pistillate form of *F. virginiana* as the mother parent and the cultivated varieties Black Hautbois and Monstreuse Hautbois as pollen parents. These were grown in the same field with large numbers of other crosses, so that the fullest possible opportunity for cross-pollination occurred. Although several clones showed yellow foliage, the hybrids in general surpassed even *F. virginiana* and crosses of cultivated sorts in the production of runner plants. Many clones have exceptionally vigorous foliage with very long petioles. Most of the hybrids flowered freely and both pistillate and staminate flowered seedlings were produced. The two forms of *F. moschata,* Black and Monstreuse Hauthois, used as pollen parents are very productive and apparently are almost completely fertile. These varieties have not been selfed and it is not known whether they would produce pistillate sorts. Except possibly in respect to the presence of pistillate seedlings the F_1 resembled the male species in all characteristics noted. The pollen parent was apparently completely dominant.

Mangelsdorf and East reported complete sterility of the F_1 between the two species *F. virginiana* and *F. moschata.* All except seven of the seedlings raised by the writers were also pistil sterile, but these seven seedlings, each represented by large clones, fruited. The sterility of most of the seedlings would seem to indicate that all are true hybrids, although cytological proof is

desirable. The finding of even a small percentage of fertile *F. virginiana* × *F. moschata* hybrids indicates that such hybrids may have been produced in the past and that *F. moschata* may have entered into garden varieties.

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Books Received

BOOKS received are acknowledged in this column, and such acknowledgment must be regarded as sufficient return for the courtesy of the sender. As far as space permits books that contain material of interest to the readers of the Journal will be reviewed in later numbers.

Creation by Evolution: A consensus of present-day knowledge as set forth by twenty-six leading authorities in nontechnical language that all may understand. Edited by Frances Mason. Pp. 392. 24 chapters. Price, $5.00. New York, The Macmillan Company, 1928.

The Psychology of Personality: An analysis of common emotional disorders. By English Bagby, Associate Professor of Psychology, University of North Carolina. Pp. 236. 14 chapters. Price, $2.50. New York, Henry Holt and Company, 1928.

The New Morality. By Durant Drake, Professor of Philosophy at Vassar College. Pp. 359. 23 chapters. Price, $2.50. New York, The Macmillan Company, 1928.

Manual of Tropical and Sub-Tropical Fruits: Excluding the banana, coconut, pineapple, citrus fruits, olive, and fig. By Wilson Popenoe, Agricultural Explorer, United States Department of Agriculture. Pp. 474. 16 chapters, 24 plates. Price, $4.50. New York, The Macmillan Company, 1927.

Beekeeping: A discussion of the life of the honeybee and of the production of honey. New and revised edition. By E. F. Phillips, Professor of Agriculture, Cornell University. Pp. 490. 24 chapters, 195 illustrations. Price, $4.00. New York, The Macmillan Company, 1928.

FurFarming for Profit. By Frank G. Ashbrook, In Charge, Division of Fur- Resources, Bureau of Biological Survey, U. S. Department of Agriculture, Washington, D. C. Pp. 300. 9 chapters, 127 illustrations. Price, $4.00. New York, The Macmillan Company, 1928.

Annual Report of the Board of Regents of the Smithsonian Institution: Showing the operations, expenditures, and condition of the institution for the year ending June 30, 1927. Pp. 580. 3 reports, and a general appendix comprising a selection of miscellaneous memoirs of interest to collaborators and correspondents of the institution, teachers, and others engaged in the promotion of knowledge. Price, $1.75. Washington, D. C., U. S. Government Printing Office.

THE GENETICS OF THE DOMESTIC FOWL

Abstracted by L. C. DUNN, *Storrs Agr. Exp. Station*, from the translation of B. F. GLESSING, *Bureau of Animal Industry, U. S. Department of Agriculture.*

THIS report of the poultry breeding studies at Anikowo covers the work of the station from its inception, in 1917, through 1923. The work was delayed in passing through the press, and was not actually issued until late in 1926. As indicated in the table of contents,* the report consists of articles on various problems by a number of workers. The most exensive paper, that by Serebrovsky, "Studies on Genetics of Domestic Fowl," has been translated and abstracted and is to be published as Parts I and II of this review. It is hoped to publish in subsequent parts abstracts of some of the other papers. Certain of these, however, have appeared elsewhere. The interesting paper of Promptov on "The Genetic Analysis of the Structure of the Pelvis," for example, has been published in the Russian *Journal of Experimental Biology*, Vol. 11, p. 128, with English summary, and more material on the same subject has just appeared in the *Journal of Genetics*. This paper, therefore, will not be abstracted.

In attempting to make the chief data and conclusions of this work available in English, we have been forced to practice a rather rigid selection and to judge the relative importance of the various contributions. The chief criteria used were newness of material or methods, and adequacy of the data presented. Detailed new data are quoted wherever given in the original.

Throughout the volume a new system of genetic nomenclature is used. This was proposed by Serebrovsky in 1921, and a short description of this system is given, chiefly as applied to poultry, in order that the terminology of the original papers retained in the abstracts may be clear to the reader.

The Nomenclature of the Genes

The purpose of the system to be described is to simplify, standardize, and internationalize genetic nomenclature. All genes before receiving a name are subjected to a classification similar to the decimal system used in cataloging books. This grouping is based on the external character which seems to be most typical for a given gene. Thus in group O are histologic and embryonic characters, in 1 physiological characters, in 8 are color characters, etc. Each of these ten main groups is then broken up into ten sub-groups numbered 0 to 9, defining the details of character expression—in the case of color characters, into basic color genes, intensifiers, inhibitors, etc. Each gene then is designated by two or more numbers which define its classification,

*GENETICS OF THE DOMESTIC FOWL: Memoirs of Anikowo Genetical Station near Moscow. Edited by Director of the Station, N. K. KOLTZOFF. Published by Commissariat of Agriculture, "Novaia Derevnia," Moscow, 1926. vii and 137 pp. Plates 1-20. Russian with English summary. Paper 15 rubles.

Preface ..... N. K. KOLTZOFF
Studies on Genetics of Domestic Fowl ..... A. S. SEREBROVSKY
The Chromosome Complexes in the Somatic Cells of the Male and Female of Domestic Chiken ..... P. J. SHIWAGO
Genetics of the Rate of Feathering ..... L. N. SAHAROVA
The Inheritance of Close-feathering ..... E. T. WASSINA
The Genetic Analysis of the Structure of the Pelvis of Domestic Fowl ..... A. N. PROMPTOV
The Inheritance of the Size of Erythrocytes ..... A. S. SEREBROVSKY
The Inheritance of the Catalase Content in the Fowl ..... N. G. SAVITSCH
Genetics of the Growth and Size ..... M. R. SOKOLOV
Studies on the Genetics of the Egg and Egg Laying ..... R. and S. SEREBROVSKY

and the number so formed is translated into letters taken from the Latin alphabet according to an arbitrary table and in such a way that a pronounceable word always will result. Thus with gene 8941 for internal pigment, 89 = tru, and 41 = le, and the gene is designated by the symbol *trule*. This symbol so derived stands for the presence of the dominant gene of the pair; when recessive or absent the letter "a" is prefixed to the symbol. Thus "*atrule*" is the recessive allelomorph of *trule*. Other prefixes, *e, i, o,* etc., are used in members of a series of multiple allelomorphs. Homozygosity is expressed by the form "*homo—trule*" or $trule._2$ Further abbreviations for laboratory or restricted use in single experiments may be made by using single letters as in ordinary genetic nomenclature. The object of the scheme, however, is to have a separate and arbitrary symbol based on an international alphabet for each gene in each animal and plant, and to eliminate the confusion arising from the haphazard designation of genes according to the language and personal peculiarities of the discoverer. Using this system, each new gene immediately may be named according to its classification, and after reference to the table for translation of numerical into alphabetical symbols, in such a way that its identity will be plain to all workers who are familiar with the system. A more complete description of the system will be found in a paper by A. S. Serebrovsky in the Proceedings of the Fifth International Congress of Genetics, Berlin, 1927.

A Short Description of the Genes of the Domestic Hen

This section contains a list of the characters of the domestic fowl classified and named according to the above system. About seventy characters (genes in Serebrovsky's notation) are classified and named, comprising those described in the literature and those studied at Anikowo. Within the limits of space available it is impossible to quote this list and the descriptions in detail. Many of them will be discussed in the ensuing sections of this abstract. Some of the new characters listed, for which, however, detailed evidence is not given, include the following:

Diquo—determining the difference in voice between the high voice of certain Bantams and the low voice of the Orloff breed.

Goqua — determining an abnormal truncation of the liver; observed especially in Cochins.

Suki—late feathering, not sex-linked and distinct from *suke*, the well-known gene for late feathering.

Sunu—determining the spreading or lateral extension of the crest in fowls possessiong *sune*, the dominant gene for presence of a crest.

Many leg feathering and plumage color characters are listed, some of which will be described in the appropriate sections.

The Genetics of Color

At present we are acquainted with the following 17 genes for color:

8114—*Tedu*—ground color gene
8115—*Tefa*—ground color gene
8215—*Tifa*—melanin
8251—*Tine*—wild pattern
8311—*Tode*—blue, inhibitor of black
8312—*Todi*—dominant white; inhibitor of color
8315—*Tofa*—inhibitor and distributor
8316—*Tofe*—henny coloring
8351—*Tone*—inhibitor—insufficiently studied
8421—*Tuge*—silver (sex linked)
8441—*Tule*—red upper parts in male
8521—*Trage*—barring
8535—*Trakla*—white streaks on feathers
8541—*Trale*—white edges on feathers
8571—*Trase*—colored tips of feathers (substituting color for white)
8572—*Trasi*—solid black in place of golden
8581—*Trate*—white ends of feathers.

Space forbids the details of the experimental material and merely a summary will be given.

Tedu — (This is the well-known ground color gene, the allelomorph of recessive white, usually referred to by the symbol C.) *Atedu* (cc) birds have white feathers, although the down may be light yellow or of variable tint, depending on the other genes present.

Thus *tuge* forms (with silver) have whitish down, while *atuge* (non-silver) have brighter yellow down. Among some Faverolle Bantams studied, two forms of recessive white chicks appeared, with greenish and with rosy down. The genetic nature of this difference was not studied. Barred Plymouth Rock × Orloff produced some recessive white chicks with darker down and these showed the white crown spot due to the barring gene *atrage*) so that at least three genes may be distinguished in recessive white chicks. The recessive whites of this type studied were from Wyandotte, Orloff, Bantam, and Cochin stocks. *Tcdu* heterozygotes *inter-se* gave 49 colored and 7 white; backcrossed to white, 75 colored and 85 white.

Tcfa—(The second color gene, the dominant allelomorph of the recessive white of the Silky fowl and of some Rose-combed Bantams — described by Bateson and Punnett 1906. This did not appear in the author's experiments.)

Tifa—Increases the development of black pigment in the down and feathers; especially obvious in the female. [This probably is identical with the dominant gene for extension of black pigment (E^m) described by Dunn, 1922.] It is difficult to describe this gene more exactly because it is dependent to so great an extent on other genes for pattern, etc. Its chief action is as a distributor or extender of one color, not necessarily black, since in certain combinations it may call forth solid white. *Tifa* is present in full black breeds, Langshan, Minorca, Black Orpington, etc. However, full black may appear in the absence of *tifa*: i. e., when *tule* (see below) is present. *Tifa* usually is more visible in the hen than in the cock. If *tifa* is added to the wild Bankiva formula the color of the cock is scarcely altered, while the hen is converted into black except for the golden hackle and small marks on the feathers. The chicks generally become black. If to the wild type is added also *todi* (which converts black into white when homozygous), then *tifa* is poorly expressed in the male. The hen, otherwise gold with white marks, becomes solid white in the presence of *tifa*, since *tifa* distributes over the whole fowl the pigment which changes into white under the activity of *todi*. *Tifa* does not enter into the composition of the wild color. It probably occurred as a dominant mutation after domestication, but very anciently, since it appears in the most diverse breeds—Langshan from China, Minorca, Spanish, Pavloff, Paduan, etc.

Tifa mendelizes normally as shown by the F_2 results tabulated below.*

The excess of *atifa* probably is due to the difficulty of identifying the *tifa* gene in such crosses, especially in chicks. The same excess appears in backcross matings where instead of a 1 : 1 ratio, 129 *tifa* : 153 *atifa* were obtained. This may indicate less vitality on the part of *tifa* chicks.

Tinc—(This gene apparently has not been described before, although in its effect on down color it bears some similarity to the gene described by Bateson and Punnett (1906), which differentiates the dark down of Brown-breasted game chicks from the brown striped down of the Black-breasted game. It also differs from the gene differentiating these down types described by Hagedoorn (1909) in that Hagedoorn's game was sex-linked, whereas *tinc* is autosomal.)

Tinc is necessary for the formation of the wild type coloration (black and brown striped) of the down of chicks. This pattern appears also in chicks of

*Cross			Found		Expected	
Tifa		*atifa*	*tifa*	*atifa*	*tifa*	*atifa*
Pavloff	×	Indian game	120	44	123	41
"	×	Orloff	45	20	48.8	16.3
"	×	Faverolle	84	37	90.7	30.3
			249	101	262.5	87.6

the Partridge Wyandotte, Brown Leghorn, and others. *Atine* chicks have a very pale wild pattern, consisting of white longitudinal stripes on the back, for example, English game, Indian game, Orloff, and others. *Tine* consequently is regarded as producing not the pattern but the dark color of the wild pattern. The difference between *tine* and *atine* forms is not clear in the adult. Cocks of both types are black-breasted red, while among wild colored hens the *tine* type is darker than the *atine*, by reason of the difference in the black or brown flecks (stippling) on the contour feathers. *Tuge* (silver) changes the reddish brown background of *tine* chicks into a lemon or greenish shade on which the white bars are barely visible, while the black parts are more distinct. *Tifa* hides the *tine* coloration, changing it into black.

Tine and *atine* segregate clearly. Two *tine* heterozygotes (English game) gave 13 *tine:* 4 *atine;* backcrosses gave 28 *tine* and 22 *atine*. Extracted *atine* bred true.

Tode. (This is the gene previously studied by several investigators, which reduces black to blue when heterozygous and to dirty white when homozygous, represented by Lippincott by *R*.) *Tode* occurs in Blue Langshans, Andalusians, and other blue breeds. No new evidence is presented.

Todi. (This is the dominant inhibitor of color characteristic of White Leghorns, and studied by Bateson and Punnett, Hadley and others). *Todi* is epistatic to all colors except the red color of the shoulders of the cock (*tule* gene). The golden borders of the hackle remain unchanged in the presence of *todi.* In general it suppresses more or less completely the black components of the wild pattern in the male, leaving the red portions unaffected, a condition known as *pile*. *Todi* and *tode* (duplex) cocks are similar; *tode* however, does not affect the golden red pigment of the hen, while *todi* reduces it greatly.

Todi is not present in the wild type formula, and its distribution is restricted practically to the Leghorn and its derivatives. It is assumed to have arisen recently, probably on the Mediterranean coast.

Tofa. Tofa is a gene of complex activity, since it both inhibits and distributes. It inhibits the black breast of the cock (in the *atifa* form). It also distributes the color of the stripe of the hackle feathers of the female to all the feathers. When black-breasted red is crossed with buff (Orpington or Cochin), the F_1 females are similar to the hens of the parent breeds. Their golden red color is more whitish or yellowish than the background of the black-breasted red, with similar blackish markings. The F_1 males are red-breasted instead of black-breasted like the black-red parent (Plate 17, Fig. 1)*. The chicks are buff, sometimes with black or brown marks on the neck. Buff male by Faverolle female gives buff hens and white cocks. The black breast of the male is replaced in this case not by red but by white, because of the presence of *tuge* (silver gene). From other crosses with Faverolle, in which white occurs as streaks in the feathers, white hens were obtained in which *tofa* had extended white throughout the feathers.

Tofa apparently enters into the genotype of those breeds in which the breast of the rooster is golden or white, and of those in which the cock and hen are colored alike: e. g., Pavloff, Paduan, Sebright, Golden Wyandotte, etc.

Tofa is difficult to recognize when *tifa* (melanic extension) is present. In such cases the presence of *tofa* may be inferred [in the absence of *tuge* (silver)], by the golden tone of the feather markings.

Tofa does not enter into the genotype of the wild Bankiva fowl, and

*All such references are to plate or figure in the original work, a number of which are in color.

probably mutated after domestication had taken place, but at a remote period, since it is widely distributed.

Tofc. *Tofc* affects the male only, producing in it the coloring peculiar to the hen. It thus may be called the gene for henny coloring. Up to the present, henny coloring has been observed only in conjunction with henny feathering. This is discussed at length below. Since henny coloring is characterized chiefly by the inhibition of black on the breast, *tofc* appears to be a weakening gene, and its effect always is reminiscent of *tofa.* *Tofc* probably occurred as a dominant mutation at the time when the hen was domesticated. *Tofc* appears to destroy full sexual dimorphism of color, and its activity can be explained only by reference to the nature of sexual dimorphism.

Sexual dimorphism, which is the rule in fowls, is most clearly expressed in the wild or Bankiva color, where the black-red pattern of the male is so different from the brownish color of the hen. Castration experiments show that the secretion of the ovary is the deciding factor in the development of henny coloring in the hen. Various arguments may be advanced to show that the sexual differences in color are not due merely to the differences in the structure of the feathers in males and females, such as existence of breeds showing structural dimorphism but no color dimorphism (Light Brahma, black races, etc.); sex differences in color in places in which there is least difference in feather character: e. g., breast. Henny coloring and henny feathering hence are not looked on as a single phenomenon. "Henny feathered" races in which color and character of the feathers change together offer some contradictions to this view, but in some races (Sebright) other genes (*tifa, tofa, tuge*) which destroy the sex dimorphism in color, even in cock-feathered types, are present. In other races from which these genes are absent, coloring and henny feathering seem to act as a unit, but for these another explanation is invoked. This explanation assumes that genes for henny feathering and coloring exist (as shown by Punnett, Morgan, and others), which operate through or in cooperation with certain sexual hormones. The further assumption is made that in the "y" chromosome of the female is carried a series of genes which distinguish the female from the male. The fact that in the Sebright a gene of this sort has been shown to be autosomal may be explained by assuming an independent dominant mutation in an autosome or by crossing over or by translocation from the "y" chromosome to one of the autosomes. Translocation is more probable, since it explains why not only henny feathering but possibly other genes adjacent to it such as henny color have been transferred to an autosome. In this case henny feathering and henny coloring would behave as though due to a single gene.

Tonc. *Tonc* is mentioned chiefly to direct the attention of other investigators to it. It simulates the activity of *tugc* (silver) but in one cross did not show sex linkage, and apparently is distinct from silver.

Tugc. (This is the sex-linked gene usually known as *silver,* which reduces buff or golden pigment to white. It has been studied by Sturtevant [1912] and has been recognized and used by several later investigators.) In addition to a brief description of the action of *tugc,* its relation to four ground colors of the fowl is discussed: i. e., black, brownish red, gold, and white. The first and second colors are due, doubtless, to black and brown pigments of different intensities. In respect to gold, it is not clear whether it is a simple pigment or whether it may be chiefly structural.

Tugc helps to distinguish between the reddish and golden elements, since if *tugc* is added to the wild type color (Black-red), the greatest changes (re-

duction of yellow) are noted in those places which had been golden, especially the borders of the feathers just at the limits of the golden shade, while the places (with one minor exception) occupied by red remain unaltered.

Tuge by itself cannot suppress reddish pigment. For this *tofa* also is necessary. *Tofa* in particular suppresses reddish (in the hen) replacing it with golden, which, under the activity of *tuge,* passes over into white.

Tuge is distinguished from *todi* (dominant white) by its relation to gold. *Tuge* inhibits gold while *todi* does not affect it (as in *pile* forms). *Tuge* has no effect on red (without assistance from *tofa*), while *todi* inhibits it, at least in the hen. In addition, *tuge* is sex-linked, while *todi* is autosomal.

Tuge does not enter into the genotype of the "wild" type. It is present in a wide variety of breeds (Brahma, Pavloff, Polish, Dorking, Japanese Bantams, etc.), indicating either that it is an ancient mutation or that it has occurred repeatedly.

Tule. (This gene, which, according to Serebrovsky, appears to control the red color of the shoulders, back, hackle, and saddle in the Black-red [male] pattern, has no certain analogies in the literature. It is similar to the "chestnut" which Agar [1924] observed and [in effect] with the gene *L* which Hays [1926] observed in Rhode Island Reds, and with a gene which had been noted by Davenport [1912] as affecting the red coloration of the shoulders in crosses of Dark Brahmas and Brown Leghorns. In the last two cases, however, the assumed gene behaved as though sex linked, whereas *tule* is said to be autosomal.)

Tule, which because of meager evidence is only tentatively established, controls the red pigment in the wild pattern and produces the red color of the iris in contrast to the recessive dark (but not the recessive yellow) color of the iris. It does not affect down color. *Atule* types include pure black breeds such as Minorca, Langshan, etc. The golden red color of the (wild type) cock involves joint activity of the two genes *tule* and *trale.* When *trale* is absent, the upper part of *tule* cocks are dark red merging into brick and cherry. If *tifa* is present, the red is largely hidden, but in the presence of *trale* the borders of hackle, saddle, and shoulder feathers remain golden or reddish. In the presence of *tule* these borders are red, but in *atule* forms they are straw colored or even grayish yellow. *Tule* is not suppressed either by *tuge* or *tofa.*

Some *atule-trale* birds observed (crossbreds from English games) had white down and as adults were colored pale straw yellow on an almost black (actually blue) ground. By removal of *trale* and *trakla* from genotypes of this kind, one should obtain fowls with a black or blackish color which, however, should be white in the down.*

Although a gene of similar effect described by Davenport appeared to be sex-linked, *tule* does not seem to be sex linked.

Tule probably is present in the wild type and *atule* has appeared as a recessive mutation. A *tule* fowl (English game) is illustrated in Fig. 13 and *atule* in Fig. 14.

Trage. (This is the well-known sex-linked gene for barring which has been studied and described by several investigators. Some further data are reported by Serebrovsky to show that *atuge-trage* (non silver barred) forms were still barred black and white, while *atuge-atifa-trage* (barring without extension or silver) were in the male black-red with white bars on both red and black ground, while in the hen barring was almost unnoticeable except in some black tail feathers.

Trakla—This is one of the least studied color characters, having been

*Recessive blacks of this kind which are white in the down now have been obtained according to a personal communication from Dr. Serebrovsky.

noted only by Davenport (1906) as a dominant gene for light shafting on colored feathers, chiefly in the female. The light center stands out sharply from the dark backgrounds formed by *tifa* or *atule* (Fig. 15), although it never has been observed alone, and usually is accompanied by light edges of the feathers or other marks. It is not known whether these other marks are due to *trakla* or other genes. The presence of the gene was established in Faverolles, Orloffs, and English Bantams (Game.) which, when crossed with Pavloff, produced chicks with black feathers variously marked and shafted with white (Plate 15, Fig. 2 and 4; Plate 16; Plate 17; Plate 13, Fig. 2 and 3), while Pavloff by Minorca gave pure black (Plate 14, Fig. 4).

Trale—Influences the color of the edges of feathers in the zone where barbules are missing; i. e., chiefly the edges of the hackle, saddle, and shoulder feathers in the male. *Trale* reduces pigment, especially black, in these areas, and the edges become light or white, although the exact color depends on other genes (*tuge, tule, etc.*). *Trale* occurs in the Bankiva and other black-breasted red types. In an *atrale* bird of this coloration the hackle, saddle, and shoulders were very dark cherry red in color. In *trale* females the edges of nearly all feathers, especially in the hackle and breast, are light, either golden (in *atuge* forms) or silver (in *tuge* forms). The action of *trale* is not suppressed by *tifa*. The *atule-trale* cock has pale straw-colored edges on a grey ground in hackle, saddle, and shoulder feathers. Other combinations of *trale* have not been observed sufficiently.

Trase—(From the illustrations and description, this undoubtedly is the character referred to in poultry literautre as *mottling*, which consists of a more or less irregular white tip on many of the colored feathers. Frequently, as in the Speckled Sussex, the base of the mottled feather may be of two colors, red with a black mark below the tip, and a white tip. In the Houdan the pattern is black with a white tip. It is characteristic of mottled breeds that not all feathers are mottled. The genetics of this pattern has not been made clear. In one cross of Davenport's it behaved as recessive to self black. Bateson and Punnett (1908) on the other hand obtained "mottled" birds from a cross of recessive white by Brown Leghorn and in subsequent crosses this mottling behaved as a dominant. It is probable, however, that this last-mentioned mottling was not the same as that described above, since the "individual feathers were barred with color, though the barring was much blurred.")

Trase is a typical distributor of color, and controls the distribution of color in the distal portion of the feather. When replaced by *atrase*, there is a more or less uncolored area at the end of the feather. The size of the white tip varies with age, widening with each molt, so that old *atrase* birds become white with colored marks (Text Fig. 18).

Atrase fowls may be illustrated by the Mottled Orloff (Plate 3). Mottling, however, occurs in two distinct forms. A cross of Houdan (mottled) by Mottled Orloff produced solid colored progeny (Plate 16, Fig. 1) showing them to be genetically different, although the mottled patterns of Houdans (Davenport) and of Orloffs both behave as recessive to solid color.

Where the white tips of mottled fowls are poorly developed, it is difficult to distinguish *atrase* forms from *trate* where the white tips are dominant. *Atrase* also influences the colored area of the feathers, frequently causing a zone of dark pigment to appear below the white tip (Text figs. 9 and 19). The expression of *trase* in the down pattern is not clear as yet. In the presence of *tifa*, *trase* and *atrase* chicks are differentiated by the greater development of white in the *tifa-atrase* form (Text fig. 21). The mottled

pattern may be combined with many different colors.

Trasi—(This gene seems not to have been suggested heretofore. Serebrovsky considers it to differentiate those types in which the individual feathers are solid black [*trasi*] unless other feather pattern genes such as barring are present, from those in which some portion of the center of the feather is free from black pigment [*atrasi*]. *The* simplest type form of *atrasi* is thence the laced feather such as occurs in the Silver or Gold Laced Wyandotte, which is a white or gold feather with a black border. However, he groups together as *atrasi* forms several laced, penciled. and variously marked types, and in this his view resembles that of Punnett [1923], who assumes "a close connection" between these pattern types. The relationship between self color and the various patterns included never has been made clear, although Punnett and Pease [1921] indicate that the crossbarred [crosspenciled] pattern of Campines is recessive or nearly so to self color.)

Trasi also is a typical distributor, controlling the distribution of black in relation to gold (or white) in the individual feather. In the presence of *trasi* the black pigment may occupy the entire surface of the feather (if it is not interfered wtih by *trale, trage, trakla, tule*). In the presence of *atrasi* the middle portion of the feather is free from black pigment. In the *atuge* (non silver) form the center is gold; in the *tuge* form it is white or silver.

In general, the feathers of the *atrasi* form are white or gold surrounded by a more or less full black border. Such for instance are the feathers of the Pavloff, Polish, Paduan, and probably the Hamburg, Wyandotte. and Sebright Bantam. When the Pavloff, which is predominantly white, is crossed with the Orloff, the hybrid is predominantly black. It follows that the Pavloff is *tifa-atrasi,* while the Orloff is *atifa-trasi*... The plumage patterns of the above *atrasi* breeds all are different. In the Sebright, Polish, and Wyandotte the feather has an even and continuous border of black. The Pavloff has only irregular black spots at the tips of the feather, and the Paduan form is still different from that of the Pavloff and Hamburg. The nature of these differences is not known, although it probably is *trakla* which distinguishes the Pavloff and Paduan types.

Trasi may be observed in the down under some conditions. *Tifa-trasi* chicks are an even black above and yellow below. In *tifa-atrasi* chicks the tips of the down feathers are light and the upper surface has peculiar marbling or speckling reminiscent of the wild pattern.

These two types segregated normally in the F_2 chicks from Pavloff × Indian Game and Pavloff × Faverolle as follows:

	Found	Expected
Black *tifa* chicks.....	105	96
Speckled *tifa* chicks.....	22	32

An *atrasi* hen backcrossed to her father, which had been black in the down, gave 14 black and 13 gray and speckled chicks.

The results of Punnett's experiments in crossing Black Langshan with Golden Pencilled Hamburg are explained by assuming that the Hamburg is *atifa-atrasi,* while the Langshan is *tifa-trasi.*

Trate—(This appears to have been discussed for the first time in this paper.) It produces a whitening of the tips of the feathers chiefly on the head and upper parts of the hackle in both sexes, and occasionally white tips on the primaries and on the feathers on the lower part of the legs. The condition is very variable. It apparently is dominant, but analysis is difficult because *trate* has for the most part been introduced from the mottled breeds (e. g., Orloff), and it has not yet been possible to separate *trate* from *trase* (mottling).

(There follow some remarks on the

occurrence of small patches of exceptional feathers in fowls heterozygous for barring which Serebrovsky calls piebalding, and which he has interpreted in another paper [1923] as due to somatic segregation.)

Classification of the Genes

The genes of fowls cannot as yet be classified by phenotypic effect, because the effect of any one gene depends on the rest of the genes present in any case; chemical or developmental classification is impossible because of insufficient knowledge, and the same lack prevents classification according to arrangement in the chromosomes. The only classification possible and useful at present is according to dominance or recessiveness to the wild (Bankiva) type. The following table thus classifies the genes discussed:

Dominant mutations*	Normal allelomorphs	Recessive mutations
	tedu	Atedu
	tefa	Atefa
Tifa	atifa	
	tine	Atine
Tode	atode	
Todi	atodi	
Tofa	atofa	
Tofe	atofe	
Tuge	atuge	
	tule	Atule
Trage	atrage	
	trakla	Atrakla
	trale	Atrale
	trase	Atrase
	trasi	Atrasi

*Mutant types begin with capital letters.

The next section contains a comparison of the genetics of color in the fowl and in mammals, in which it is concluded that there are some similarities between hair and down colors although down and feather colors, and feather and hair colors are quite dissimilar. This is followed (pp. 34-43 in the original) by a description of the chief combinations of the fourteen genes discussed above. It is impossible to abstract this extensive table, but we have extracted from it the following genotypes proposed by Serebrovsky for a number of poultry varieties.

Table Showing the Assumed Genotypes of Some Color Varieties

\+ = dominant allelomorph present
— = dominant allelomorph absent

tedu	tifa	tine	tode	todi	tofa	tuge	tule	trage	trakla	trale	trase	trasi	trate	
+	+	—	+	—	—	—	—	—	—	—	+	+	—	White splashed Andalusian
+	+	—	—	—	+	—	+	—	+	+	+	—	+	Gold Polish & Sebright Bantam
+	+	—	—	—	+	—	+	—	—	+	+	—	+	Golden Pavloff
+	+	—	—	—	—	+	+?	+	—	+?	+	+	—	Barred Rock
[1]+	+	+	—	—	—	+	+	—	—	—	—	+	—	Houdan
+	+	—[1]	—	—	—	—	+	—	—	—	+	+	+	White Crested Black Polish
+	+	—	—	—	—	—	+	—	—	—	+	+	—	Black Langshan; Black Minorca
+	—	+	—	—	—	+	+	—	+	+	+	+	—	Silver Dorking and Duckwing
+	—	+	—	—	—	+	—	—	+	+	+	+	—	Dark Dorking
+	—	+	—	—	—	—	+	—	+	+	+	+	—?	Wild Type; Partridge Wyandotte; Brown Leghorn
+	—	—	—	—	—	+	+	—	+	+	+	+	—	Faverolle
+	—	—	—	+	—	—	+	—	+	+	+	+	—	Pile
+	—	—	—	—	+	+	+	—	—?	+	+	+	—	Light Brahma
+	—	—	—	—	—	—	+	—	—	—	+	+	+	Mottled Orloff

[1]— In the original; obviously a misprint.

The "Proved" Sire in Dairy Improvement

A FACTOR of great importance in the building up of a daily herd is the use of a good proved bull, says O. E. Reed, Chief of the Bureau of Dairy Industry, United States Department of Agriculture.

To prove a bull, according to the standards set by the bureau, it is necessary to compare the yearly records of at least his first five daughters with the records of their dams. Such a comparison indicates the probable value of a bull to a herd.

The record of one outstanding sire that was proved in a Vermont dariy-herd-improvement association was pointed out by Mr. Reed. The first reports received of this bull included records of 15 daughters and their dams. The dams were, without exception, much better than the average dairy cows of this country. The lowest producer had a record of 14 pounds of butterfat, and the average of all the dams was 386 pounds. The 15 daughters of this sire, however, averaged 545 pounds of butterfat. Here was an average gain of 159 pounds of butterfat, or more than 40 per cent. Even more remarkable, every one of the 15 daughters was a better producer than her dam. The sire is to be credited with most of the improvement. He possessed to a remarkable degree what is known as "prepotence" in milk production.

Last year, according to Mr. Reed, only 200 dairy bulls were proved in 660 dairy-herd-improvement associations. It was found that of this number only one in six was still alive at the time he was proved. Some proved bulls should be slaughtered, because their records are bad, but the prepotent bulls which have demonstrated their ability to sire daughters more productive than their dams should be kept as long as they are useful.

When the exchange of bulls becomes a regular practice they can be kept until they are proved. This important phase of the work in the dairy industry is not receiving the attention that it should, and much greater effort than is now being expended should be put forth to preserve the lives of meritorious bulls. The general practice of using only good proved bulls, Mr. Reed believes, will result in a material increase in the production of the dairy cows of the country.

—U. S. Dept. of Agriculture.

VARIEGATION AND CHROMOSOMES IN PETUNIA

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VARIEGATED PETUNIA FLOWERS

Figure 8

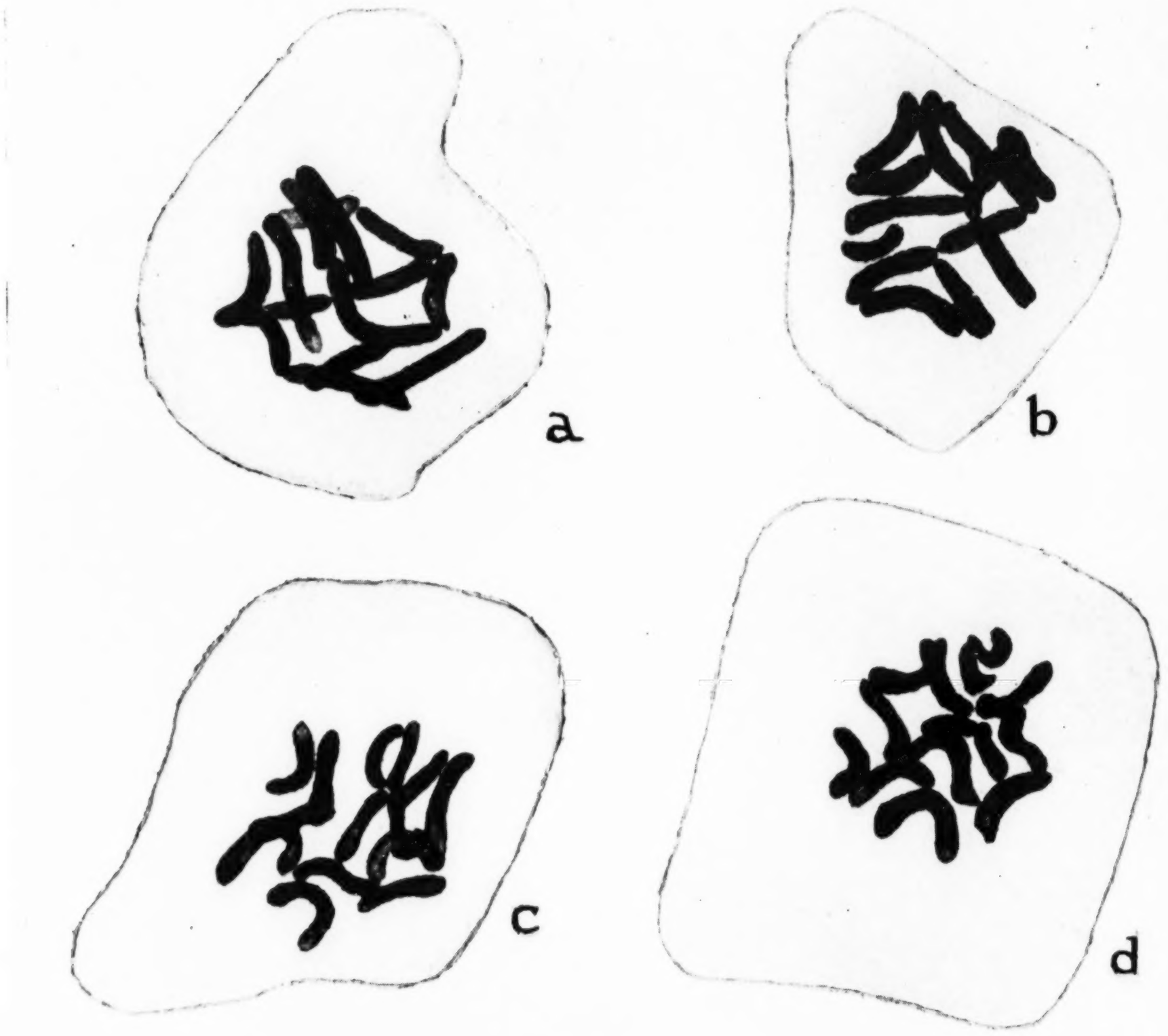
Natural size photogaph of the flowers of a variegated strain of *Petunia violacea,* showing variation in size from large purple flowers, (a) to small lilac ones (e). All these flowers are from a single plant. The lilac pigment photographs white; the purple, dark.

FOR several years I have had in my Institute a variegated strain of *Petunia violacea* Lind. This strain was isolated in 1914 from a population of plants obtained from seeds supplied by Vilmorin-Andrieux (Paris). A striking feature of this strain is the variability in the size and color of flowers. Figure 8 shows various types of flowers of this strain, from large purple (Figure 8*a*) to small lilac (Figure 8*d* and *e*). Between these two extremes we see intermediate types (Figure 8, *b* and *c*) with a decreased amount of purple pigment. All these flowers were taken from one individual. There are also individuals showing only large purple flowers and others which have only small lilac ones. The seeds collected from an individual with large purple flowers give a progeny analogous to that of an individual with small lilac flowers.

TWO KINDS OF FLOWERS

Figure 9

On the left is shown a purple flower with a lilac sector (white in the photograph); on the right is a flower having a comparatively large amount of purple pigment on a lilac background. Seeds from such a plant produce three kinds of plants (1) with small lilac flowers; (2) with large purple flowers; (3) and with intermediate flower types, as in this case.



CHROMOSOMES OF VARIEGATED PETUNIA

Figure 10

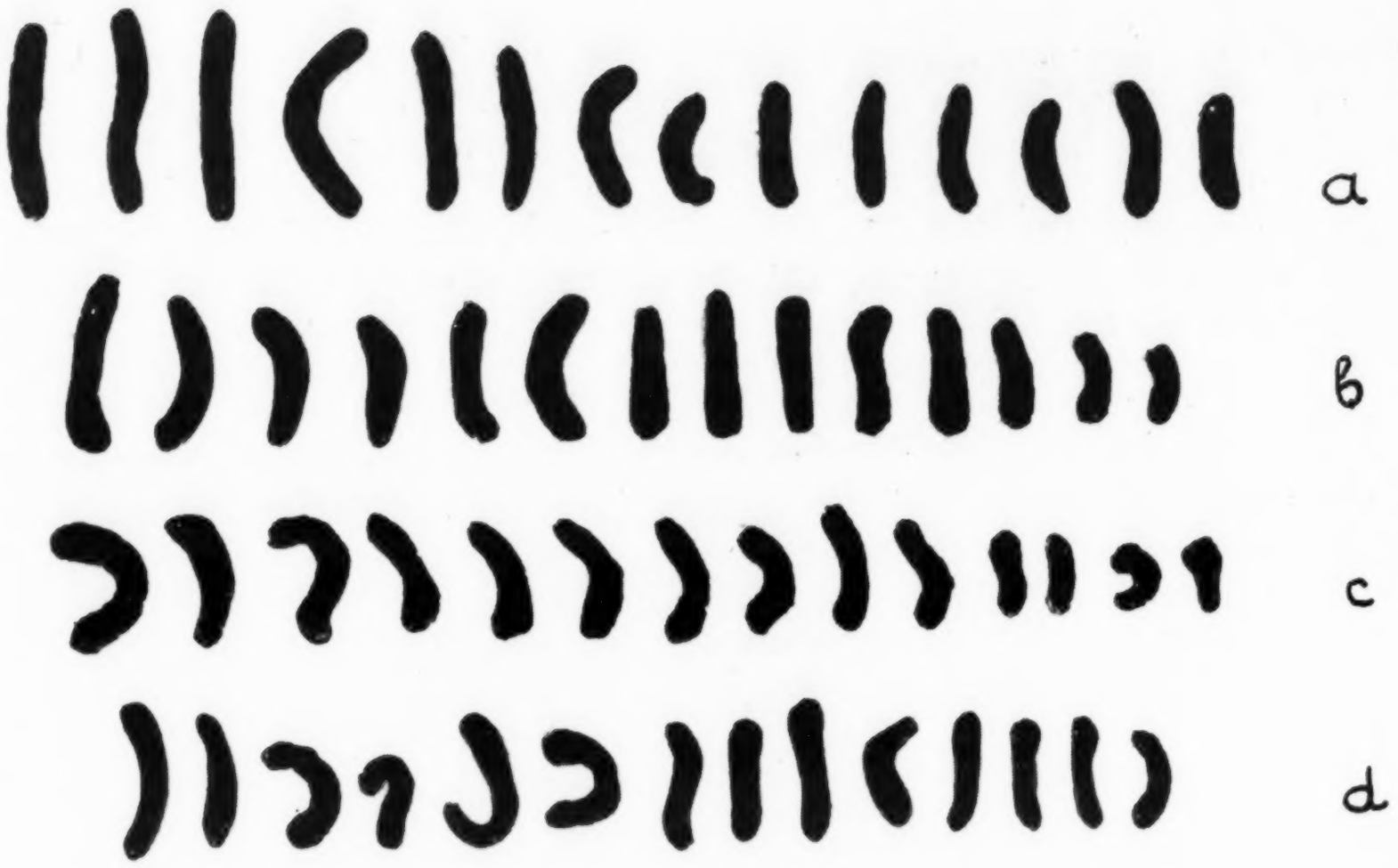
Drawings from somatic mitoses showing: *a*, *b* chromosomes of large purple flowers; *c*, *d*, from small lilac ones. Note difference in chromosome sizes, the large purple flowers having larger chromosomes than the small lilac ones.

In both cases we obtain individuals with large purple flowers, others with small lilac ones and others showing various intermediate types as concerns size and color of flowers. *Petunia violacea* is mostly self-incompatible and in order to get a progeny I crossed two individuals showing the same type of flowers, i. e., the flowers half purple and half lilac or having a lilac sector only, the remaining part of the corolla being purple. Figure 9 shows such a flower (on the left side). On the same shoot we see a flower which is typical of the rest of this plant. (Figure 9 on the right side). It has a comparatively large amount of purple pigment on a lilac background. Two such plants, when crossed, produce also a polymorphic progeny showing a large scale of variation from large purple to small lilac flowers. This variation seems to be phenotypical. The plants with large purple flowers and those with small ones belong to the same genotype. Some crossing experiments carried out by me in collaboration with Mrs. Sachs Skalinska

VARIEGATION IN A CROSS

Figure 11

All the flowers are taken from a single plant, a second generation hybrid between the varigated strain of *Petunia violacea* and *P. grandiflora*. Among 237 second generation plants there were seven combining the varigation from *violacea* with the giant flowers of *P. grandiflora*. Natural size.



DIFFERENCES IN CHROMOSOME SIZE

Figure 12

The large chromosome complements (a, b) are from large purple flowers; the smaller chromosomes (c, d) are from small lilac flowers. Such chromosome differences can be demonstrated in the flower from a single plant, suggesting that the size and color differences of the flowers are due to somatic segregation of the chromosomes. It is probable, however, that some agency outside the chromosomes determines the chromosome size, and thus the characteristics of the flower.

(*Comp. Rend Soc. Sc. Varsovie.* Vol. IX, 1916) indicate also that the large scale of variation characteristic of this variegated strain depends upon one gene.

From the cytological point of view, however, the problem is not so simple. The variegation is connected in Petunia with the size of the chromosomes. Petunia has seven pairs of chromosomes which are unequal in size. I observed these chromosomes in the buds of young flowers. I examined the chromosomes only in the middle part of the flower buds. On an average the chromosomes of large purple flowers are larger (Figure 10, *a, b,* and Figure 12, *a, b*) than those of small lilac ones. (Figure 10, *c, d* and Figure 12, *c, d*). But often one can find also complements of smaller chromosomes in the cells of large purple flowers. The differences as to the size and shape between particular chromosomes are usually greater in small lilac flowers than in large purple ones. But sometimes two cells with different chromosome complements may be seen side by side.

During the reduction divisions in any kind of flowers complements of larger as well as of smaller chromosomes may be seen in meiosis and as a result two daughter cells appear, one of which possesses a complement of larger chromosomes and another one of smaller.

Is it probable that the differences between large purple flowers and small lilac ones are due to the differences in chromosome sizes? We are accustomed to believe that the differences

in size and color are determined by the genes located in the chromosome. But in the case of the variegated strain of Petunia many chromosomes of each complement, or perhaps all of them, are mostly larger in large purple flowers than in small lilac ones. It seems probable therefore that outside of the chromosomes there is a cause which determines the size of chromosomes and consequently the size and color of flowers.

Some authors believe that the genes are composed of gene elements, and that in the case of color variegation the pigment-producing and non-pigment-producing gene elements become segregated in the somatic tissue, in the course of development, by the mechanism of mitosis. But in the case of Petunia we observe a segregation in two chromosome complements, one composed of larger and the second of smaller chromosomes.

The variegation of *Petunia violacea* is transmitted from generation to generation independently of other characters. After crossing the variegated strain of *P. violacea* with *P. grandiflora*, Hort, we observe in the F_2 generation new types which are the result of union of "variegation" with the giant flowers of *P. grandiflora*.

Petunia grandiflora, which I used for crossing, possesses very large flowers of a dark violet color. These are uniform as regards size and color of the corolla. The differences in size are relatively small. The F_1 generation was intermediate as concerns the corolla size. Size and color of flowers were uniform. In the F_2 generation I obtained a segregation. Among 237 F_2 plants there were 230 uniform indiuals with large flowers (Figure 11). The large variegated flowers of the F_2 generation are shown in Figure 11. All of them are taken from one F_2 plant. These F_2 variegated plants intercrossed give in the F_3 generation a polymorphic line showing a large scale of variation from large violet flowers to small flowers with a decreased amount of violet pigment (like F_2 plants). These latter flowers are, however, larger than the large purple flowers of the parental variegated strain of *P. violacea*.

The cytological slides presented in this paper were made by my assistant, Miss H. Sobolewska, in 1927 and 1928, in Professor Z. Woycicki's laboratory in Warsaw, to whom I am very grateful for this assistance.

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